International Library of Technology
354

Molding

289 Illustrations

Prepared Under Supervision of
A. B. CLEMENS,
DIRECTOR, MECHANICAL SCHOOLS
INTERNATIONAL CORRESPONDENCE SCHOOLS

GREEN-SAND MOLDING
CORE MAKING
MACHINE MOLDING
DRY-SAND AND LOAM WORK

Published by
INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PA.
1926

Printed in U. S. A.

PRESS OF
INTERNATIONAL TEXTBOOK COMPANY
SCRANTON, PA.

354 88667

PREFACE

The volumes of the International Library of Technology are made up of Instruction Papers, or Sections, comprising the various courses of instruction for students of the International Correspondence Schools. The original manuscripts are prepared by persons thoroughly qualified both technically and by experience to write with authority, and in many cases they are regularly employed elsewhere in practical work as experts. The manuscripts are then carefully edited to make them suitable for correspondence instruction. The Instruction Papers are written clearly and in the simplest language possible, so as to make them readily understood by all students. Necessary technical expressions are clearly explained when introduced.

The great majority of our students wish to prepare themselves for advancement in their vocations or to qualify for more congenial occupations. Usually they are employed and able to devote only a few hours a day to study. Therefore every effort must be made to give them practical and accurate information in clear and concise form and to make this information include all of the essentials but none of the non-essentials. To make the text clear, illustrations are used freely. These illustrations are especially made by our own Illustrating Department in order to adapt them fully to the requirements of the text.

In the table of contents that immediately follows are given the titles of the Sections included in this volume, and under each title are listed the main topics discussed.

INTERNATIONAL TEXTBOOK COMPANY

B

CONTENTS

NOTE.—This volume is made up of a number of separate Sections, the page numbers of which usually begin with 1. To enable the reader to distinguish between the different Sections, each one is designated by a number preceded by a Section mark (§), which appears at the top of each page, opposite the page number. In this list of contents, the Section number is given following the title of the Section, and under each title appears a full synopsis of the subjects treated. This table of contents will enable the reader to find readily any topic covered.

GREEN-SAND MOLDING

(PART 1)

IRON MOLDING

INTRODUCTION

1. Founding is the art of making metal castings. It consists in mixing and melting the metals, making the molds, pouring the metal into the molds, and cleaning or preparing the castings either for the machine shop or for shipment.

The molds are generally made of green sand, dry sand, loam or metal. **Green-sand molding** involves the making of castings in molds that are composed entirely of sand in a damp state, or that have their surfaces *skin-dried.*

Dry-sand molding involves the making of castings in molds that are made with sand in a damp state, after which the sand is dried in an oven, or otherwise, so as to remove all moisture and leave the body of the mold dry and firm.

In **loam molding,** the castings are made in molds constructed with sweeps and skeletons of patterns; a mixture of loamy sand and other material is used to form the face of the mold, brickwork forming the outer and inner supports. This class of work, like dry-sand molding, requires thorough drying before the metal is poured into the molds.

The Sections treating of green-sand molding will deal exclusively with the making of green-sand molds by hand.

DEFINITIONS

2. Some foundry terms, tools, and materials will be defined or explained in the following articles and other definitions and explanations will be given from time to time throughout the text:

A **pattern** in the foundry is a form by the use of which a mold may be made. Patterns are usually made of wood or metal in one or more pieces. A pattern made in one piece is called a *solid pattern;* when made in two or more pieces, it is called a *parted pattern.*

Draft is a term used to denote that a pattern is tapered, the larger face of the pattern being at the parting line or surface of the mold. An allowance for draft is made to facilitate the drawing of the pattern from the sand.

Shake is the allowance that is made in the size of a pattern to permit it to be rapped sidewise in order to loosen it in the mold so that it may be removed without making the casting oversize. Such an allowance is generally made only on patterns under 4 inches across.

Shrinkage is the allowance made on a pattern to compensate for the contraction of the casting in cooling.

3. A **flask** is a frame or box that holds the sand in which the mold is made. A flask may be made of wood or metal, in two or more parts. When composed of two parts, the one that stands underneath while the mold is being poured is called the *drag*, or *nowel*, and the portion that is molded last and that stands uppermost while the casting is being poured is called the *cope*. When a flask has more than two parts, the portions between the cope and the drag are called *intermediate parts*, or *cheeks*. These terms are applied both to the parts of the flask and to the parts of the mold contained in the flask.

The **molding board**, sometimes called the *follow board*, is the board or plate on which the pattern is placed while ramming the sand into the drag.

The **bottom board** is the board or plate that is placed on top of the drag and fastened there before rolling it over;

hence, it becomes the bottom of the mold during the subsequent molding and casting operations.

A **sprue** is a wooden or metal pin that is used to make a hole in the cope through which metal is poured into the mold. The hole that is made by this pin and the metal that is cast in it is each also called a sprue.

Risers or **feed-heads** are openings from the top of the mold through the cope. They may extend only to the surface of the cope or to the top of a part built to the required height above the cope. Metal entering the riser indicates when the mold is full, and the riser also provides a supply of liquid metal to make up for the shrinkage of the casting. Risers may be placed directly on a casting or at one side and connected to it, but they should be as close as possible to the parts they are to feed. Metal remaining in a riser is also called a riser.

A **gate** is an opening leading from a sprue or riser to the mold, or it is the metal that is cast in this opening.

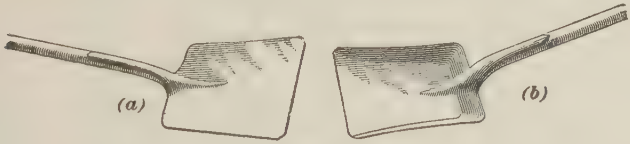


FIG. 1

A **core** is the name applied to any body of sand that projects into a mold. A core may be left by the pattern or may be formed separately and placed in the mold. In the latter case, the pattern must be provided with *core prints* or projections that form recesses to receive the ends of the core.

4. Molding sand is any sand used to make molds. It usually consists of a natural mixture of sharp sand and clay, the latter being necessary to make it adhere, or stick together.

Partings are materials used to prevent two surfaces of a mold from adhering. Sharp or burned sand, called *parting sand*, is the most common parting.

Fireclay is any clay capable of withstanding intense heat. It is used for lining ladles, cupolas, and any place where great heat must be resisted.

Facing is a general term applied to any material used for lining the walls of a mold for the purpose of improving the surface of the casting.

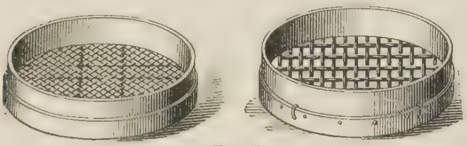


Fig. 2

5. Two common kinds of shovels are shown in Fig. 1. The flat shovel shown in (*a*) is generally used for bench molding and light floor work, but the one with turned up edges shown in (*b*) is used for digging holes and for heavy molding.

A **riddle** is a tool used for sifting sand or for removing coarse material from the sand. The hand riddle, shown in Fig. 2, is composed of a circular frame, the bottom of which is covered with wire cloth. The meshes, or openings of riddles, range from the fineness of a flour sieve to openings $\frac{1}{8}$ inch square. Coarser riddles are made, but they are not commonly used for riddling sand.

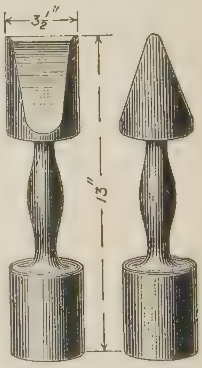


Fig. 3

A **rammer** is a tool used for tamping the sand in a mold. A *hand rammer*, shown in Fig. 3, is usually made of wood; it is used for small work that requires light ramming. A *floor rammer*, two views of which are shown in Fig. 4, is used for large work, and where harder ramming is needed than in small molds. One end, called the *peen*, is made wedge-shaped and the other end, called the *butt*, is round. The peen and butt ends of a floor rammer may be

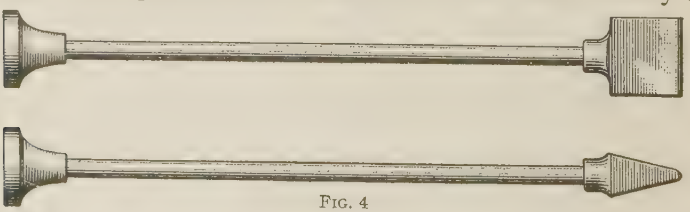


Fig. 4

made of brass or iron joined by an iron pipe or a wood stem that also serves as a handle.

A **gate cutter** is a tool for cutting gates in molds. Various forms of gate cutters are used, depending on the requirements of the mold that is being made. A common form is shown in Fig. 5 (*a*). **Slicks** are tools for finishing the surface of a mold. One form of slick is shown in Fig. 5 (*b*). A **lifter,** one form of which is shown in (*c*), is intended principally for the removal of loose sand from the mold but it is also frequently used for much the same purpose as a slick.

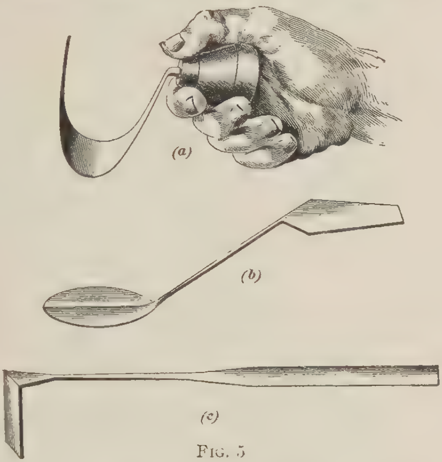


FIG. 5

A **strike bar** is a straight bar of wood or iron used to smooth molds on the bottom of the drag and the top of the cope.

FIG. 6

6. A **draw-nail,** or **draw-spike,** is a piece of metal, sharp at one end, used in drawing a pattern from the mold. It is driven into the pattern and holds by friction.

A **draw-hook** is a metal hook with a handle, used for drawing patterns that are supplied with special draw-plates to receive the end of the hook.

A **draw-screw** is a rod having a thread at one end, and is used for drawing patterns that are provided with draw-plates.

Draw- and **rapping plates** are metal plates fastened on patterns and intended to receive the ends of draw-hooks, draw-screws, or rapping irons. Frequently a draw-screw is used by

screwing it into the hole in the draw-plate. The pattern may be loosened by rapping sidewise on the draw-screw; but it is better practice to use a rapping iron in a separate and unthreaded hole in the draw-plate.

A **swab** is a piece of hemp, flax or sponge that is used to dampen the joint of a mold before drawing the pattern. The swab is dipped in water and then lightly squeezed out, after which it is passed over the joint, care being taken not to get the sand too wet along the joint between the pattern and sand. Where delicate swabbing is required, as in bench molding, or the wetting of small bodies of sand, a sponge with a wire or long thin nail passed through it, as shown in Fig. 6 (*b*), is often used. The sponge holds the water until squeezed out with the hand and the wire or nail directs the water to the spot to be dampened. In making the swab shown in (*a*), a piece of fine-grade, long-fiber hemp rope is tied at one end with a fine wire or string to form a handle, and the other end *teased out* by pulling it through a comb made by driving some nails through a board and allowing the points to extend beyond the board. While in use, the board forming the comb may be fastened to a bench or a table. In making such swabs, some molders use a fine string that will not unravel in water or when dampened. This string is cut into lengths of about 1 foot and a bunch of them tied at one end to form a handle. Good swabs can, however, be obtained very cheaply from any foundry supply house.

FIG. 7

TEMPERING SAND

7. Mixing Sand.—In mixing or tempering sand by hand, the shovel should be used in such a manner as to scatter the sand, as shown in Figs. 7 and 8. This is done by giving the shovel a twist with the hand that holds the handle end. When shoveling sand from one place to another without attempting to mix it, the sand is sometimes allowed to leave the shovel in a solid mass, as shown in Fig. 9. This method of shoveling permits the sand to be thrown to a greater distance, and hence

FIG. 8

is used when shoveling sand from place to place, as from a car to a bin.

A molder should never work with a dirty shovel. When in use the shovel should be kept clean by scraping as shown in Fig. 10. When put away for the night, or if not in constant use, a shovel should be cleaned of all dirt and oiled with a greasy rag to prevent it from getting rusty. Nothing denotes the poor or slovenly molder more than working with a dirty shovel.

A molder or helper should learn to shovel either right- or left-handed, so as to be able to take either side of a sand heap when working with an assistant; note the different relative

Fig. 9

Fig. 10

Fig. 11

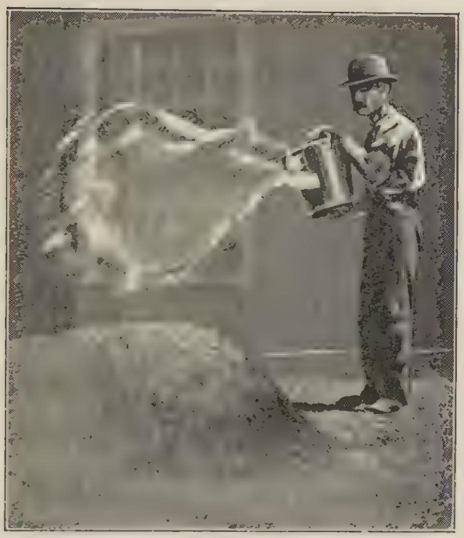


Fig 12

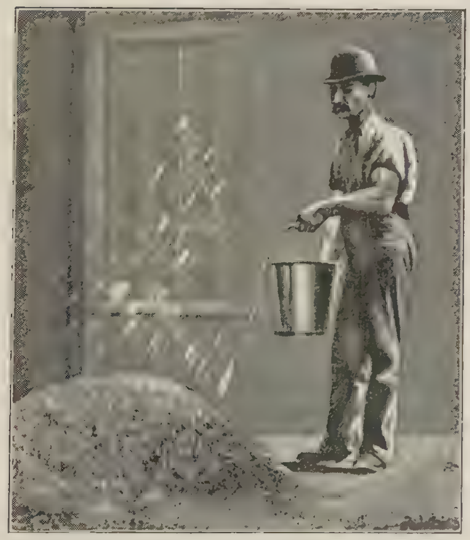


Fig. 13

positions of the two men in Figs. 8 and 11. A clear space of 1 or 2 feet should be maintained between the pile from which

FIG. 14

the sand is being shoveled and that on which it is thrown, as shown in Figs. 9 and 11. If this is not done, some of the sand will escape thorough mixing.

FIG. 15

8. **Wetting Down Sand.**—In throwing water on a sand pile with a bucket or hose, it should never be thrown in a body

on one spot, as that will form mud holes and involve a loss of time and labor in mixing the mud with drier sand in order to temper it. If the sand is very dry, water should be sprinkled on it from a hose, or by being thrown from a bucket, as in Fig. 12. When the sand has been dampened nearly to its right temper, so as to require but little more wetting, it should be sprinkled by hand from the bucket, as shown in Fig. 13.

9. Riddling Sand.—In riddling sand by hand, the riddle should not be held rigidly, as shown in Fig. 14, but should be held loosely, so that the butt of the hand can strike, or jar, the rim of the riddle as it is swung from one side to the other, after the manner shown in Fig. 15. Hitting the rim of the riddle with the butt of the hand causes a jar that makes the sand pass through the meshes much more freely than if it were held rigidly, as in Fig. 14.

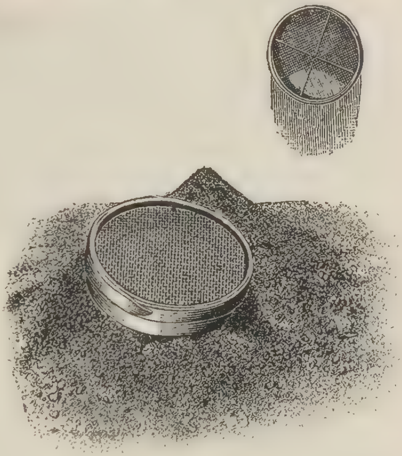


Fig. 16

10. Care of Riddles. When riddles are not in use, they should not be thrown on the damp ground or on a sand pile with the mesh side down, as the meshes will be clogged with sand in such a manner as to hinder the passage of sand through the screen and also cause the wires to rust away very rapidly. The riddles should be placed either on the sand heap with the mesh side up, or hung on a nail, as shown in Fig. 16. A skilled molder can be detected by the way in which he handles his riddle or his shovel.

MAKING THE MOLDS

11. General Principles of Molding.—Molds in which metals are cast are made in many different ways, but the results are always the same; recesses having the shape of the casting required are made in the sand or other molding material. A common method of forming these molds is to pack molding sand around a wooden pattern that is of the same shape as the casting that is to be made. The pattern is then drawn from the sand, thus leaving an impression—that is, the mold—in which the metal is cast.

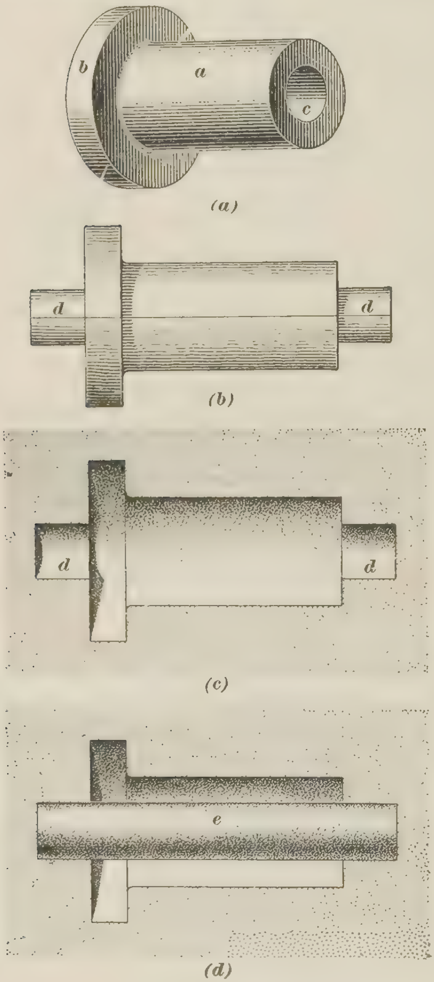


FIG. 17

12. A casting, its pattern, and the mold is shown in Fig. 17. The casting, which is shown in (*a*), has a cylindrical body *a* and a flange *b* at one end. There is also a hole *c* extending through the casting. The pattern is shown in (*b*). When patterns cannot be so made that a hollow in the casting will be properly formed, a core is used. In order to provide a support for the core, core prints *d* are put on the pattern. The appearance of the mold after the

pattern has been drawn from the sand is shown in (*c*). The recesses *d* are made by the core prints and are themselves usually called core prints. To make the hole through the casting the core *e*, shown in (*d*), is put into the mold. The making of cores is treated in the Section entitled *Core Making*. When metal is poured into this mold, a casting like that shown in (*a*) is made.

The processes of making molds will be explained by means of several examples. These processes are applicable to many different kinds of molds and they may for that reason be varied to suit special requirements.

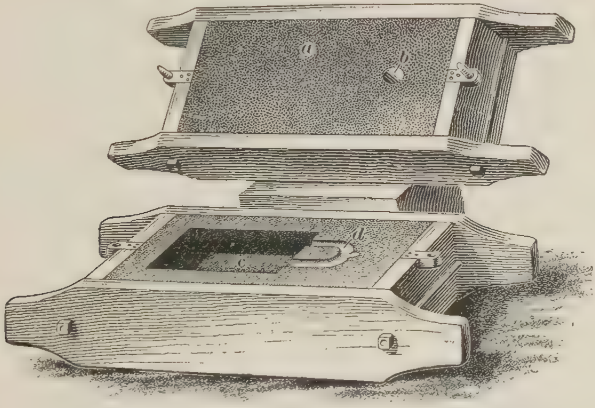


FIG. 18

13. Molding a Plate.—As the first example, let it be required to make the mold for a 6″ × 10″ flat plate 2 inches thick. The pattern is put in a drag on a follow board, and the flask is filled with sand and rammed. The back of the drag is then struck off smooth, a bottom board is put on, and the mold is turned over. When the follow board is removed the pattern imbedded in the sand is exposed. The side of the drag in which the pattern is located is called the *joint side* because it will later form the joint between the cope and the drag. Parting sand is now sprinkled on the joint and the cope is put on the drag. The sprue pin is then put in position at one side of the pattern, the cope is filled with sand and rammed, and the sprue pin is drawn, thus leaving a hole through the cope to the joint. The cope is then lifted off as illustrated in Fig. 18,

showing the joint surface a and sprue b. The pattern is next drawn from the drag, thus leaving the mold c in which the plate is to be cast. The gate d is cut from the mold to the print of

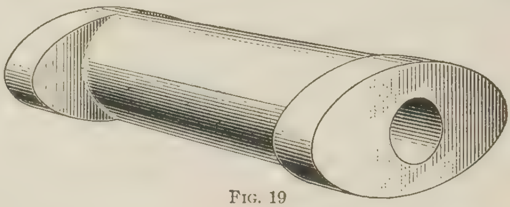


FIG. 19

the lower end of the sprue pin in the joint surface of the drag and the mold is ready to close and to be poured, the metal entering the mold through the sprue and gate. This process is called molding by *rolling over*.

14. Split Pattern With Straight Core.—For the next example let it be required to make the mold for the casting shown in Fig. 19. The casting is 12 inches long and the round body is 3 inches in diameter; the flange at each end is elliptical and is 6 inches long and 3 inches wide. There is a hole $1\frac{1}{2}$ inches in diameter extending through the casting.

The pattern for this casting is shown in Fig. 20. It is made in two parts, and is therefore called a parted pattern. The drag half of the pattern is shown below and the cope half above. The drag half has no pins, as they would keep the pattern from lying flat on the follow board. The cope half of the pattern has dowel-pins to hold it in place on the drag half of the pattern. The pattern has no hole, but is provided with core prints a that make recesses in the sand to hold the ends of the core.

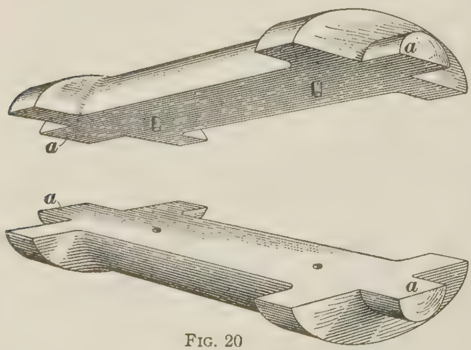


FIG. 20

15. Flask.—The flask should be of a size that will leave a sand margin, which is the width on the joint, between the pattern and the flask, wide enough to prevent the flask from being burned, and there should be enough sand below the mold so that the bottom board will not be burned. The width of the margin and the depth of the flask are therefore controlled by the amount of metal to be contained in the casting. A margin of 2 or 3 inches should be allowed for the casting under consideration and there should be from 4 to 5 inches of sand between the casting and the bottom board. The casting is 12 inches long, and, allowing 3 inches at each end, the flask should therefore be 18 inches long. Allowing the same margin on the sides gives a flask 12 inches wide. The sprue should be not less than 1 or 2 inches from the flask and some patterns may require a little wider margin on the side where the sprue is to be placed than on the other sides. Each half of this pattern is $1\frac{1}{2}$ inches thick and a 6-inch drag will therefore have $4\frac{1}{2}$ inches of sand between the casting and the bottom board. The cope should be about 1 inch thicker, to prevent too rapid cooling of the casting. The drag may therefore be 12 in. × 18 in. × 6 in. and the cope 12 in. × 18 in. × 7 in.

Fig. 21

16. Making the Drag Mold.—To make the drag, the follow board is first placed so that it has a solid bearing and will not be sprung when the sand is rammed. The drag is then set on the board, care being taken to see that it bears evenly at all points and does not rock. The pattern should lie flat on the follow board and as near as possible to the center of the flask. Some fine sand is riddled on the pattern and, if necessary,

tucked by hand around the pattern and into the corners. This *facing sand*, as it is called, will make a smoother casting than would be obtained if coarse sand were used against the pattern. The facing sand should be passed through a riddle about No. 8 size and should cover the pattern to a depth of from 1 to $1\frac{1}{2}$ inches. The facing sand may be backed up with coarser sand and the flask heaped up 4 or 5 inches. The mold is then ready to be rammed. Fig. 21 shows the proper way to hold the rammer. In starting to ram a mold, the peen end is used first around the inside of the flask and as close as possible around the outline of the pattern. The flask is then heaped up with sand and the mold is butt rammed. This part of the ramming may be hastened by tramping the mold with the feet before the rammer is used. When the ramming is finished, the surface of the sand will be more or less uneven and it may be slightly above or below the edge of the flask. If the sand is above the edge of the flask, the excess may be removed by means of a strike bar, as shown in Fig. 22, and if the flask is not full of sand, enough sand is added and rammed to fill it.

Fig. 22

Fig. 23

When the sand in the flask has been leveled off, a little loose sand is sprinkled over the surface, as shown in Fig. 23, and the bottom board is put on and rubbed back and forth, as illustrated

in Fig. 24, until it reaches an even bearing all over the mold. The bottom board and the follow board with the drag between them are then clamped together and the whole rolled over, as shown in Fig. 25. The clamps are then removed and the follow board taken off, thus having the joint side of the mold uppermost with the half pattern imbedded in it.

FIG. 24

17. Making the Cope Mold.—All loose sand is removed from the exposed surface of the pattern by means of a brush or bellows and the cope half of the pattern is put in place. Then the joint is sprinkled with parting sand and the cope is put on the drag, care being taken to blow off the excess of parting sand. The facing sand is then riddled on as before and the sprue is set up at one side with sand piled around it, if necessary, to hold it in place. The cope is then filled and rammed in the same manner as the drag.

When the cope has been struck off, the sprue is drawn and the top end of the sprue hole made funnel-shaped by hand. The cope is then lifted off and set on edge at one side of the drag. Loose sand that may have fallen into the sprue hole or on the surface of the drag should first be removed. This can usually be done with the bellows.

FIG. 25

The mold should now be wetted, preparatory to drawing the pattern. The wetting is done by using a swab to direct a small stream of water on the sand around the outline of the pattern, as shown in Fig. 26. By this process the danger of breaking the mold when the pattern is drawn is greatly lessened.

18. Rapping and Drawing Pattern.—After the pattern has been swabbed, it is rapped by striking on the side of a bar that has been inserted in the hole in the rapping plate,

Fig. 26

as shown in Fig. 27. It is better, however, to have two holes in the rapping plate, one for the rapping bar, and the other for the draw-screw. Sometimes the draw-screw is made to serve for both purposes; this arrangement may answer where the patterns are light, but for large patterns there should be a

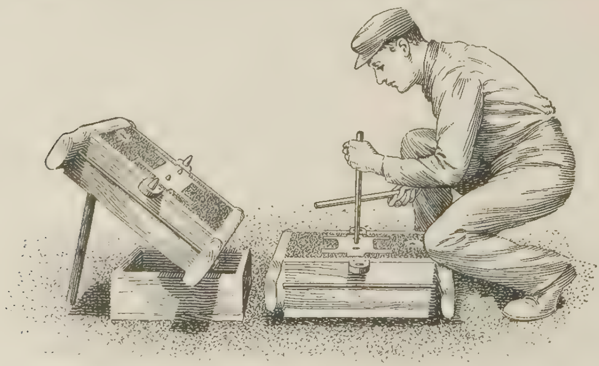


Fig. 27

rapping hole as well as a draw-screw hole. If the screw hole is made to serve for the rapping hole also, the thread in the screw plate is soon destroyed, even if the rapping is done on

the draw-screw. Too much care cannot be taken to have good arrangements for rapping and drawing patterns, as not only the wear of the pattern is prevented, but labor is also saved. After the pattern has been loosened by rapping, it is drawn by introducing the draw-hook or draw-screw, as shown in Fig. 28. While drawing the pattern, it should be rapped gently, as shown in the illustration. The rapping plate on the pattern shown in Fig. 28 is made large enough to contain two holes, one for the draw-screw and one for the rapping bar.

Fig. 28

19. Finishing the Mold.—The pattern having been rapped and drawn, the mold is finished with the trowel and the slick, the latter tool being shown in Fig. 5, (*b*). The lifter, shown in (*c*), is used to remove any loose sand from the mold or to finish corners. The gates for connecting the sprue with the mold are cut by means of a gate cutter. The form of gate cutter illustrated in Fig. 5 (*a*) consists of a thin blade of brass or steel bent to the required form and provided with a handle. Another form of gate cutter is shown in use in Fig. 29.

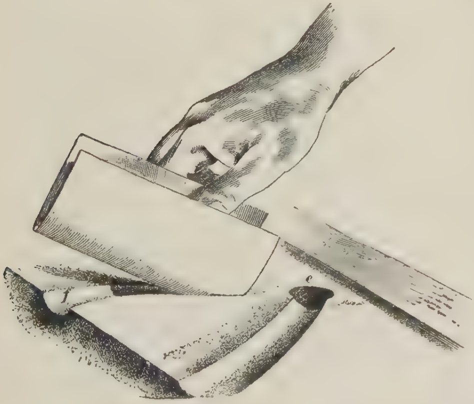


Fig. 29

It consists of a thin sheet of tin or brass bent to the required form and is used as shown in the illustration.

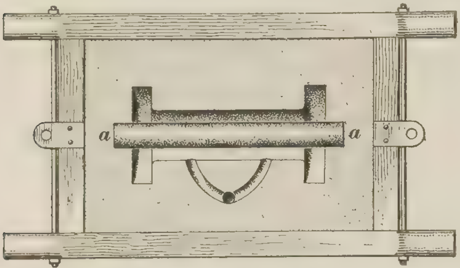


Fig. 30

After the gates *f* are cut to the bottom of the sprue or riser *e*, Fig. 29, they should be smoothed firmly with the fingers, so as to press down all the loose sand. If this is not done, the iron, when running through them, will carry dirt into the casting. With some molding sands, the top edge of the pouring gates should be carefully wet with a swab or sponge before the gates are smoothed down. In using water in this way around gates, extra care must be exercised not to make any portion of the sand too wet; for this might cause the iron to blow as it passed into the mold and result in spoiling the casting.

20. Setting Core and Closing Mold.—After the mold is finished and the gates are cut, the core is set and the mold is closed. The pattern shown in Fig. 20 is provided with core prints which make recesses at each end of the mold for the ends of the core to rest in, as shown at *a* Fig. 30. This illustration also shows the position of the sprue and the gates. The cope is now put on the drag, thus closing the mold, which is then clamped and poured as shown in Fig. 31. When the metal has set, the flask is removed, the casting taken from the sand, and the gates

Fig. 31

knocked off. After the casting has cooled sufficiently, it is taken to the cleaning room.

21. Mold for Pipe Bend.—The casting shown in section in Fig. 32 is a special pipe bend with flanged ends and the pattern for it is shown in Fig. 33, in which (*a*) is a view looking down on the pattern and (*b*) a view looking at the end of the short branch *a* in view (*a*). The core prints are shown in each view at *b* and *c* and the pattern is parted along the line *d e*. The making of the drag mold is the same as the one just described, but the making of the cope differs somewhat.

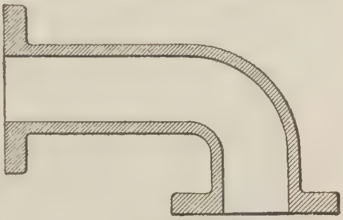


FIG. 32

22. When the drag mold has been turned over and the follow board removed, the cope pattern is put in position and parting sand is sprinkled on the joint. The mold is shown completed up to this point in Fig. 34. The top view of the mold is shown in (*a*) and a section through the mold in (*b*). This pattern would ordinarily be placed cornerwise in the mold so that a smaller flask would be used than is here shown, but the arrangement of the pattern in Fig. 34 was chosen for simplicity of illustration. A little facing sand is first riddled on the pattern and the sprue *a* is set. Sand is then put into the flask up to the top of the flange, care being always taken to keep facing sand next to the pattern. The risers *b* are then put in position on top of the flanges and held by heaping a little sand around them.

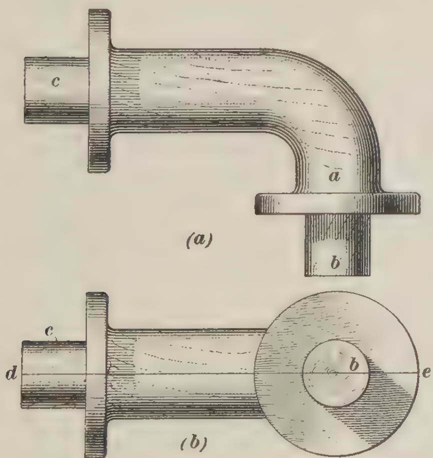


FIG. 33

23. Large copes cannot be rammed hard enough to permit the required amount of handling, and the sand must therefore be supported in some way to keep it from falling out when the cope is lifted off. Cross-bars c, often called *chuck bars*, are

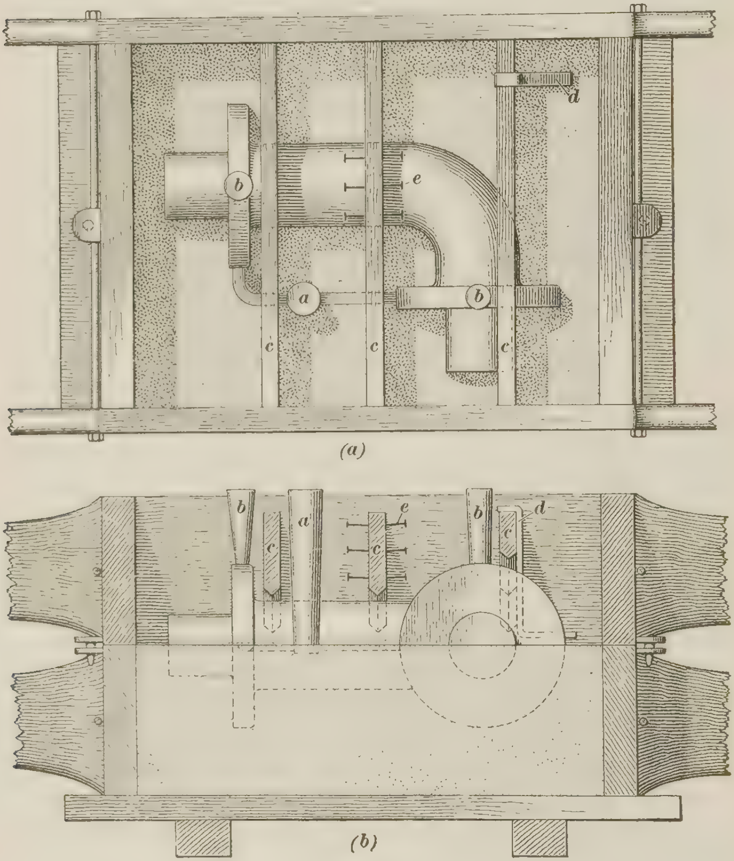


Fig. 34

frequently put into copes for this purpose. These bars extend to a point near the joint and are cut away to approximately follow the outline of the pattern. The sand may be further supported by means of gaggers d. Gaggers are pieces of iron that are either bent or cast to the required shape to support

the sand in the lower surface of the cope. When the sand is not so deep as to require the use of gaggers, nails *e* may be driven into the sides of the bars to support the sand.

24. When cross-bars are used, the sand must be tucked under them by hand or by using the peen end of the rammer

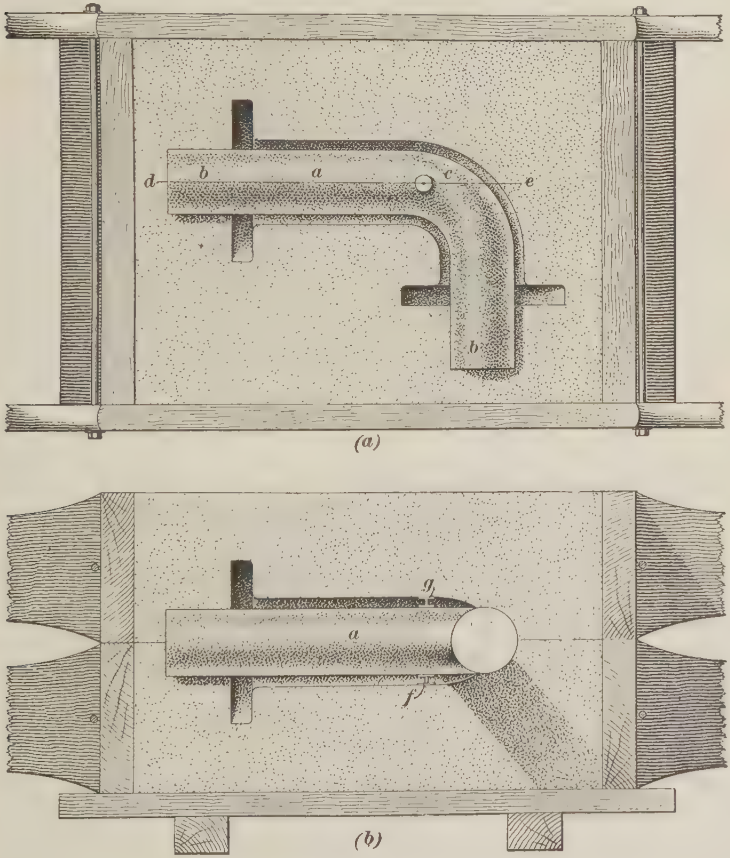


Fig. 35

which is held at an angle of about 45° to the side of the bar. In other respects the ramming of this cope is the same as previously described. After the cope has been rammed and the sand on the back of the mold smoothed off, the mold is vented

by sticking a vent wire through the sand over the pattern in several places. The vent holes thus made and the risers provide a means of escape for the air in the mold and for gases contained in the iron. If not allowed to escape, these gases would make the casting defective.

When the cope has been vented, the sprue and riser pins are drawn and the mouth of the sprue is made funnel shaped. The opening of the risers need, however, not be touched except to see that there is no loose sand that might fall into the mold. The cope is then lifted off and the pattern is drawn in the usual way.

25. After the mold shown in Fig. 34 has been completed, the core is set as shown in Fig. 35, in which (*a*) is a view looking down on the drag showing the core *a* in place. The core is supported in the core print *b* at each end, but this support is insufficient for the part at *c*. The necessary support may be given in the manner illustrated in (*b*), which shows the cope in place; but all of the mold in front of the line *d e* in (*a*) is supposed to have been cut away, the core being shown again at *a*. The part of the core that is to be supported rests on a chaplet *f* in (*b*), which rests on the bottom of the mold. The core is, however, lighter than iron and hence, if it were free to do so, the core would float in the iron. The tendency of the core to float must be counteracted in some way such as by placing a chaplet *g* on top of the core. The double-headed chaplet shown is but one of the many varieties of chaplets made to suit different conditions.

26. Tramping the Mold.—The molder sometimes hastens the work of ramming large molds by tramping them, as shown in Fig. 36. After peening around the mold next to the flask, he steps on top of the sand heaped up on the middle of the mold and moves across in a series of short jumps, keeping both feet together. He then steps to one side and treads across again, jumping in the same manner. The molder continues this process until he has covered the whole area of the top of the mold, when he steps on the ground, rams the surface with the butt of the rammer, and strikes off the top of the mold.

27. Clamping Cope and Anchoring Pattern.—Deep copes must sometimes be clamped to the drags when hard ramming is necessary. If the cope were not clamped, sand might be rammed into the joint between the cope and the drag, thus forcing them apart. The forcing of the cope off the drag does not injure the mold until it is clamped in preparation for pouring. Clamping the mold will force the cope back into contact with the drag by crushing the sand and injuring the mold more or less.

Fig. 36

A heavy pattern will sometimes drop out of the cope when it is lifted off and deep patterns, having but little draft, are apt to pull down some sand, thus injuring the mold. One or more draw-hooks or screws may be attached to the back of the pattern before the cope is filled and rammed to hold it in place while the cope is being lifted off. These irons extend through the cope to the top surface, where they may be fastened after the cope has been rammed and before it is lifted off. After the cope is lifted off the fastenings are released and the irons withdrawn. When the cope pattern is drawn, the holes made by the irons that held the pattern in place are patched by the molder, so that the surface of the casting will not be marred.

BENCH MOLDING

28. Advantages of Bench Molding.—In order to save time and labor in making some kinds of small castings, benches are used to support the flasks during the molding. The molders that do this class of work are called *bench molders*. In some cases, a dozen or more patterns may be attached to a plate or pattern board and the whole so finished that as soon as the pattern is drawn, the mold may be closed. While many founders make a specialty of bench molding, many large foundries could utilize benches and snap flasks for making

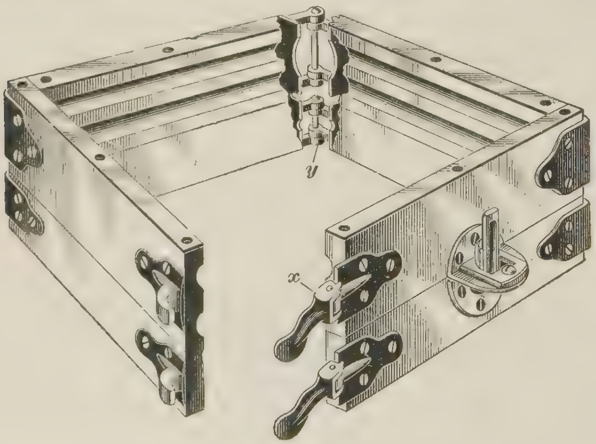


Fig. 37

some of their very light castings, instead of molding them on the floor after the manner of heavy work. Not only are benches used for convenience in ramming up snap flasks, but also for the ordinary small wooden and iron flasks, ranging from 10 to 18 inches, square or round. Snap flasks, however, are employed very largely in bench molding and properly belong to this class of foundry work.

29. Snap Flasks.—A snap flask is a small flask hinged as shown in Figs. 37 and 38, so that it can be opened and removed from the completed mold. A very large number and

variety of small light castings are made in snap flasks. For common use on the bench, these flasks range from 10 to 18 inches square, if of the form shown in Fig. 37, and from 10 to 16 inches in diameter, if of the form shown in Fig. 38, the cope and drag usually being from 2 to 6 inches deep. For ramming molds on the floor, larger sizes are used. Snap flasks may also be oblong or of any other shape desired. Those shown in Figs. 37 and 38 are constructed with clasps and hinges, as seen at *x* and *y*. The use of one flask to make any number of molds is thus permitted.

30. Snap-Flask Limitations.—It is chiefly molds that have little side pressure when being poured that are made in snap flasks; for when the flask is removed from the mold there is little to prevent the pressure of the fluid metal from bursting the mold outwardly. To prevent snap-flask molds from bursting, the molder places cribs or frames around the molds, which keep the sand in place. Fixed cross-bars cannot be used in the copes of snap flasks; but loose bars may, when necessary, be put in after the cope is partly filled.

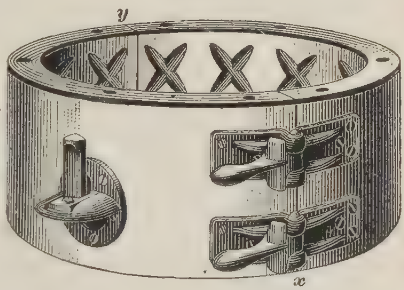


Fig. 38

The cope is made of sand that is lighter than iron and that will float on iron if permitted to do so. Molds that are left in the flask while being poured may be clamped to keep the cope from being lifted; but molds made in snap flasks cannot be clamped. The copes of such molds are usually held down by weights. These weights must not, however, be heavy enough to crush the mold. The greater the surface of the cope that is in contact with the metal, the greater is the force tending to lift the cope off the drag. Snap flasks cannot therefore be used for molds in which so much cope surface is exposed to the metal that the cope cannot be held down with weights that will not crush the mold. For instance, a stove door should not be

FIG. 39

cast in a snap flask, since the large area over which the iron can exert a lifting influence tends to separate the cope and drag. Large flat pieces that have a considerable portion of their area cut away by holes, such as stove-door frames, etc., can be cast in snap flasks on account of the small lifting area they present to the cope.

31. Making a Bench Mold.—The first operations of bench molding as carried on in a stove foundry are shown in Fig. 39. The cope and drag of a snap flask are shown at *a* and *d*,

FIG. 40

in (*a*). The pattern *b* is placed on the molding board *c*, ready for use. The drag *d* is placed, with the dowel-pin *e* of the drag between the nails or other fastening, on the molding board, as shown at *f*. The molder sets his riddle *g* on top of the flask and shovels it full of sand from the pile under his bench. He then riddles an inch or so of sand over the face of the pattern, as shown in (*b*), after which he shovels in sand until there is quite a heap above the flask. He then rams all around the edge of the mold close to the flask with the handle of the shovel *k*, as shown in (*c*).

32. Next he takes the bench rammers *l* and rams the sand all over the middle of the mold with the rammers held flat, pushing both rammers down together, as shown in (*d*). As soon as he has gone over the mold once or twice in this way, he rams down hard with the butts all over the mold, as shown in Fig. 40. The next operation is to strike off the mold, which is done by sawing a straightedge back and forth across the top of the mold in a zigzag manner, leaving the top smooth. The top is then sprinkled over with a handful of molding sand, and the bottom board is placed on and rubbed down with a rotating movement to a good smooth bed on the sand and against the flask. The flask is then rolled over, as shown in Fig. 41. The molding board is then removed, the top of the mold cleaned off and smoothed up, parting sand sprinkled over the mold, the cope *a* fitted on to the drag *d*, and the sprue pin *m* put in place, as shown in Fig. 42 (*a*). Sand is again riddled all over the pattern and rammed as before. The top is smoothed off with the strike *o* and the sprue pin *m* removed with a drawspike *n*, as shown in (*b*).

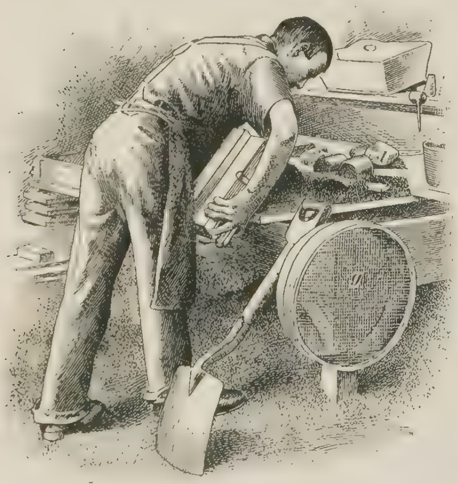


Fig. 41

33. After the sprue pin is withdrawn, the sand around the top of the sprue is rounded off with the fingers and packed firmly. The cope is then lifted off carefully, so that the sand will not be loosened, and placed standing on edge on the bench, as shown at *a* in (*c*). The bellows *h* is used to blow off any loose sand or dust around the pattern or on top of the drag, as shown. With the sponge and quill *p*, water is dripped all around the

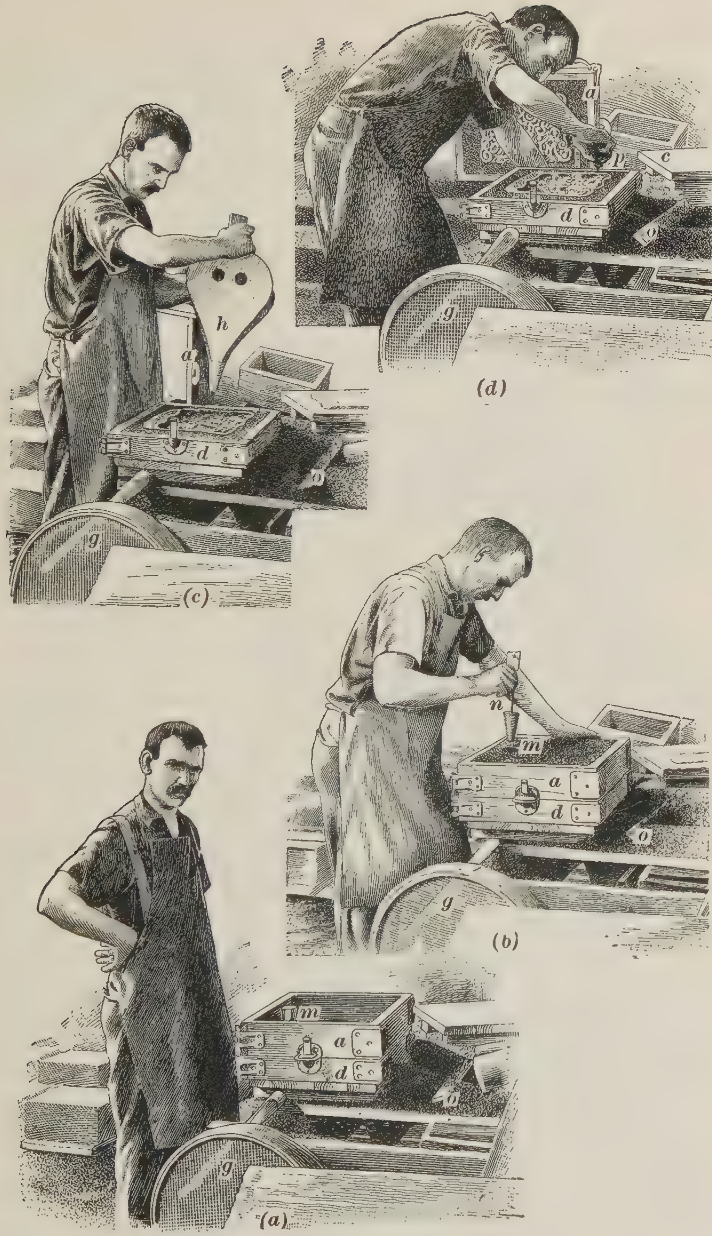


Fig. 42

sand near the edge of the pattern, as shown in (*d*). The sponge is fastened to the quill, so that when the sponge is full of water it can be squeezed in such a way as to let a few drops fall from the end of the quill or quite a little stream of water from the sponge. This moisture on the sand makes it firmer, so that the pattern can be removed without displacing the sand. The pattern is now ready to draw, which is done with draw-pins, as shown in Fig. 43. The pattern for the gates is then removed, or, if gate patterns are not used, gates are cut to connect the sprue with the mold, and the mold is smoothed with a finishing tool, and, if there are any defects, the necessary patching is done on both the cope and the drag. The cope is then replaced, the snap flask removed by loosening the catches *q* and *r*, and both cope and drag are taken off at the same time, as shown in Fig. 44 (*a*). The flask is placed on its side in a convenient position, and a crib *s* in (*b*) put on the mold to keep it in good shape and keep the iron from running out at the joint while pouring. The mold is carried out on the floor and placed in the row with the molds already there, as shown in Fig. 45. When the day's molding has been finished the molds are poured, as shown in Fig. 46. Pouring is begun at the rear of the floor, so that the shaking out can be started without interfering with the subsequent pouring. Also, in case not enough iron is furnished for all, those molds remaining will not be in the way of the molder next day. Fig. 46 gives a good idea of the appearance of a foundry floor when the molds are being poured.

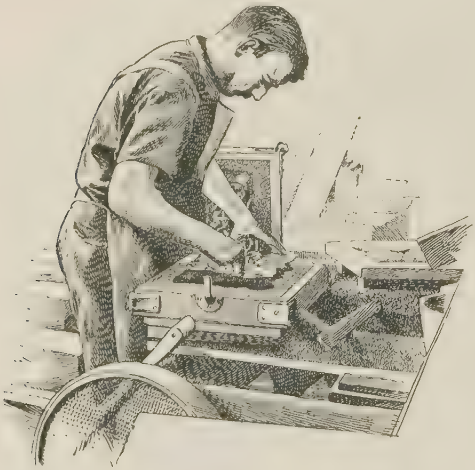


Fig. 43

34. Pouring Off.—In foundries where small work forms the largest part of the output, it is customary to stop the molding in the early part of the afternoon and pour off the molds

(b)

(a)

Fig. 44

that have been made since morning. The molten metal is brought to the molder usually in traveling ladles, but sometimes by hand ladles. Any dirt that can be skimmed off is removed

and the molder pours the molten metal into the mold, as shown in Fig. 46. A cast-iron weight *t* is placed on the mold before pouring, and the molder holds the ladle as low as possible and takes care not to strike it against anything. He brings the ladle as close to the mold as he can without touching it and turns the ladle gradually until a small stream of metal starts into the mold. By watching the metal closely, he is able to stop pouring before the metal runs over the side of the mold. When he has poured all the molds that he can pour completely with the one ladleful, the balance is poured into small pig molds, which are merely small cast-iron **V** troughs about 10 inches long. The weights *t* are then shifted to other molds before pouring the next ladle of metal. The purpose of these weights is to prevent the metal from lifting or displacing the copes on the molds. The letters in Fig. 46 have the same signification as in Figs. 42 to 44.

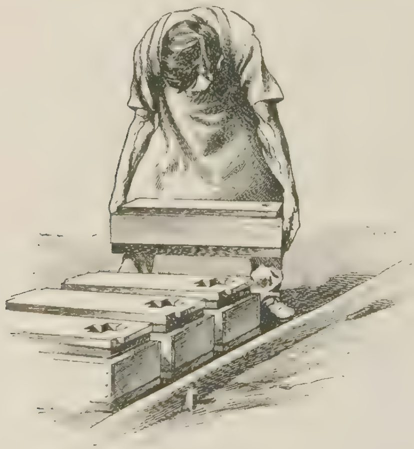


Fig. 45

35. Shaking Out and Tempering the Sand. — The pouring having been finished, the molder starts in to remove the castings from the sand. This process is commonly called shaking out the castings. The cribs *s*, Fig. 46, are removed from the molds and placed in a pile *w*. The castings are removed with tongs and placed at one side in a pile, and the sand is cleaned off the bottom boards *u*, which are placed on the pile of bottom boards *v*. When all the castings have been removed and the sand cleaned off the bottom boards, the sand is tempered as previously explained and piled in the middle of the floor. The bench on which the molder has his tools is moved over the sand pile and made ready for the next day's

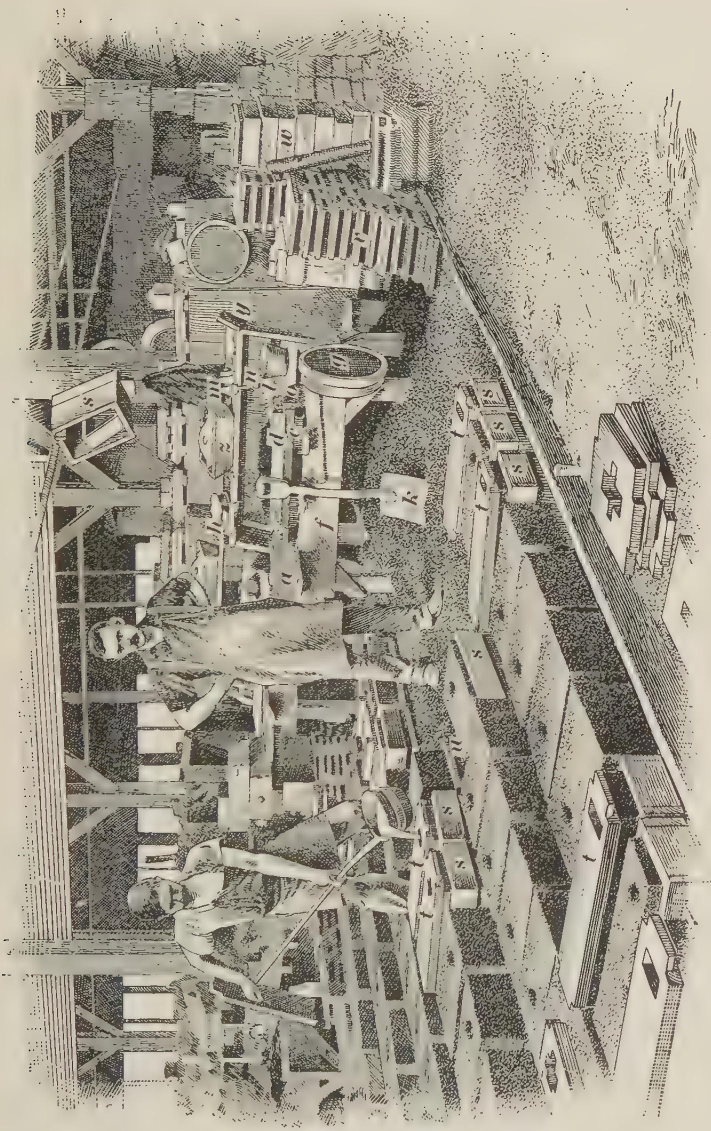


Fig. 46

work. The molder shovels the sand from under the bench, and the bench is moved along so that he can keep up with the sand as he uses it, and at the same time have room for the molds as they are finishd. By working in this manner the molder does not have to go far for his sand nor to place the molds. This arrangement is a great convenience and it saves the molder time. In some cases a wheel is placed on each of the back legs, so that the molder can move the bench back without the help of another man.

36. The arrangement of tools about the bench and on it is also for the purpose of saving time. The cope *a*, the drag *d*, the molding board *c*, the riddle *g*, the shovel *k*, the hand rammers *l*, the sprue pins *m*, the draw-spike *n*, the strike *o*, the cribs *s*, the bottom boards *v*, a brush *y* for clearing off dirt, and a tool box *z*, in which small finishing and other tools are kept, are all on or near the bench. In this way everything is convenient for rapid and expeditious work. For some classes of bench molding, the benches are stationary, being placed along the wall near the windows. In such cases it is necessary to bring the sand to the bench and take the molds away.

NOTICE TO THE STUDENT

READ CAREFULLY BEFORE ANSWERING EXAMINATION QUESTIONS

That the student may understand what is expected in answer to the Examination Questions at the end of each Section, the following examples of questions and answers are given. It will be noted that the answers are short, yet tell all that is asked for in the questions.

In answering the Examination Questions, the student should read each question carefully to make sure that he understands what is required, then write an answer that states clearly just what is asked for in the question, using his own words as far as possible. By following this plan he will obtain the greatest benefit from his course. If unable to understand

a question, or to answer it after having studied the text carefully, he should write to the Schools at once for help.

QUESTION 1.—What is a snap flask?

ANSWER.—A snap flask is a small flask having hinges so that it can be removed from the mold.

QUESTION 2.—What is a pattern?

ANSWER.—A form for making a mold.

QUESTION 3.—What is a molding board?

ANSWER.—A board on which the pattern is placed while ramming the drag.

QUESTION 4.—What is molding sand?

ANSWER.—It is usually a natural mixture of sharp sand and clay which will stick together and serve for making molds.

GREEN-SAND MOLDING
(PART 2)

IRON MOLDING—(Continued)

DETAILS OF THE MOLD

JOINTS

1. Making Joints.—The simplest form of joint and the one most used is the straight joint, the manner of making which was described in *Green-Sand Molding*, Part 1. Joints for parting circular forms are shown in Figs. 1 and 2. When the pattern is divided as shown in Fig. 1, it is customary to make the mold with half the pattern in the drag and half in the cope. The parting line of the pattern and the parting line of the mold are made to lie in the same plane, so that in lifting the cope, half the pattern is lifted with it and the other half remains in the drag. If the solid pattern shown in Fig. 2 is to be used with a straight joint in the mold, it is necessary to bed half the pattern in the cope temporarily. The drag is then put on and rammed up, the mold rolled over, and the cope shaken out, placed on the drag, and rammed up again.

2. While the method of dividing the pattern as shown in Fig. 1 can be followed to advantage in many cases, there are other cases in which it is better to make the pattern in one piece. Another method of molding when a solid circular pattern is used is to place the pattern on a follow board and ram up the

drag in the ordinary way. The mold is then turned over and the joint cut down to one of the two forms shown at x and y, Fig. 2.

The joint shown on the right at x is bad practice, as some sand will often be left sticking in the sharp angular pocket

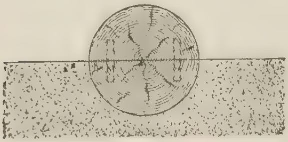


FIG. 1

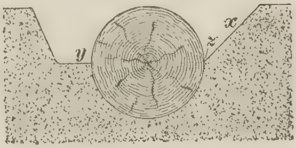
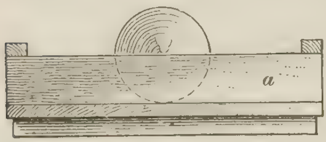


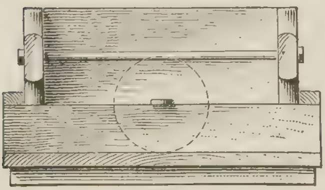
FIG. 2

formed against the pattern at z. When sand does stick in such pockets, it is difficult to patch them without causing a heavy "fin" on the casting or taking chances of a "crush" at the joint. Such a form also gives a very poor bearing for gaggers, the setting of which is explained later.

By making a joint as at y, on the left of Fig. 2, every opportunity is afforded for a good bearing for gaggers and for obtaining a clean lift. Should any of the joints break, the patching required can be done without much danger of leaving large fins on the casting or causing the mold to crush, owing to the flat surface at the joint, which gives a good guide for patching any broken edges. It is chiefly for heavy castings that cutting down in this manner is practiced.



(a)



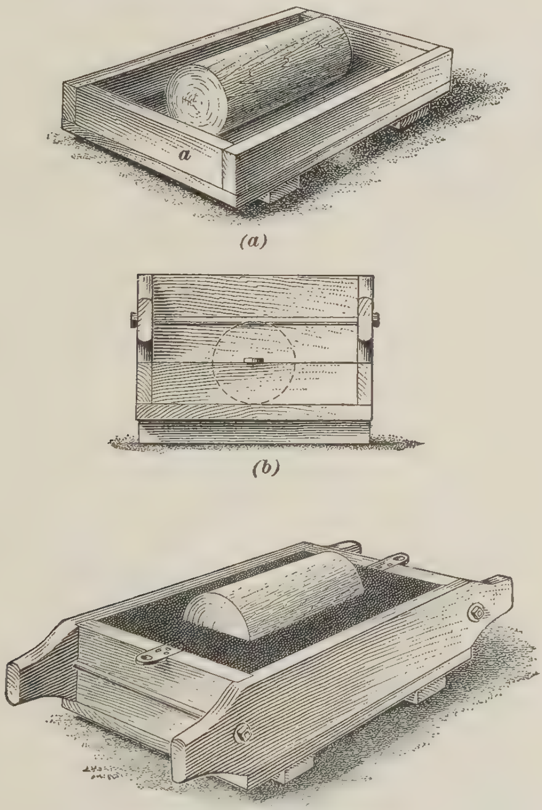
(b)

FIG. 3

These two methods of parting the mold when using a solid pattern are rarely employed except when the cope is shallow or it is desired to avoid cutting the bars of the flask to conform to the shape of the pattern. Small patterns are usually divided as in Fig. 1 or provided with follow boards.

3. The flat joint with a solid pattern may be made in several ways. The match board shown in Fig. 3 (*a*) is frequently

used. The follow board is provided with a make-up piece *a* that is hollowed out to take the part of the pattern that goes in the cope. The drag, Fig. 3 (*b*), may be put on this match board and rammed in the usual way. In turning the drag



(*a*) (*b*) (*c*)

FIG. 4

care must be taken to prevent any movement of the match board, as the pattern would also be moved and the mold spoiled.

4. When only a few molds are required, a *match flask* may be made, by ramming very hard a flask having the pattern bedded in the joint side. Match flasks may be made in several

ways; but the following style will prove suitable in most instances: The pattern is laid on a follow board as shown in Fig. 4 (*a*) and a frame *a* is placed around it. On this frame the flask is to rest, so that its joint side will be held even with the joint to be made in the mold. If there is any difference in the pattern between the cope and the drag side, the cope side should be placed uppermost. The match flask is then put over the pattern and rested on the frame, as shown in (*b*), care being taken to place the flask so that there will be ample margin on all sides of the pattern. The flask may now be filled with sand and rammed very hard, after which the excess sand is struck off, a bottom

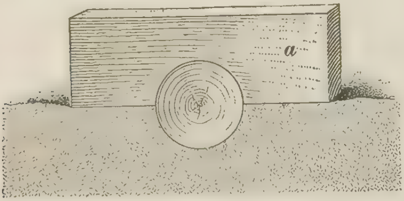


FIG. 5

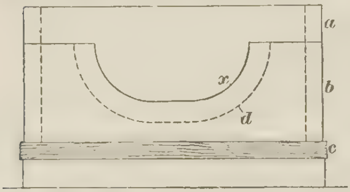


FIG. 6

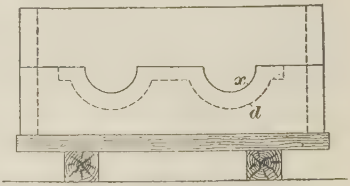


FIG. 7

board is put on, and the flask is rolled over. If the joint side of the mold is not hard enough, it may now be rammed again, sand being added as may be needed. The excess sand is then struck off, thus leaving the pattern imbedded in the sand, as

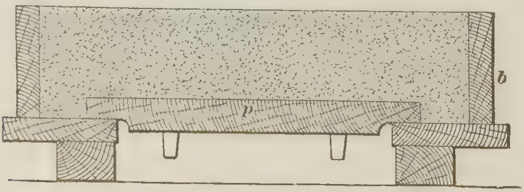


FIG. 8

shown in (*c*). This sand match is then used to support the pattern while the drag is being rammed and if well made it may be used for several molds.

Instead of using the frame *a* in (*a*), the pattern may be temporarily bedded in the floor a trifle deeper than the desired

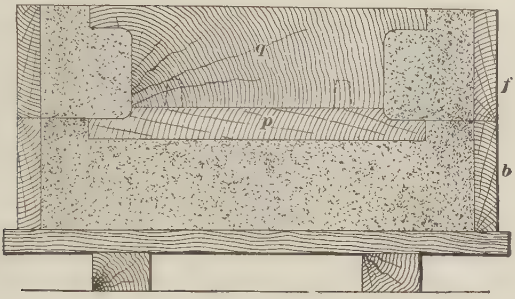


FIG. 9

joint. The joint surface is made by the use of a sweep board *a*, Fig. 5, which removes the surplus sand. The sweep board should be long enough to reach over the width of the space that will be covered by the flask. When the joint has been made, the flask is rammed up in the usual way.

5. Joints for Irregular Forms.—Fig. 6 illustrates a method of making joints by having the parting line of the cope

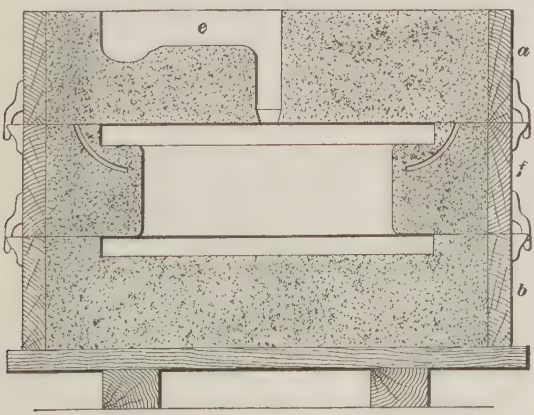


FIG. 10

and drag conform to the shape of the joint of the pattern. The illustration represents the end view of the cope *a*, drag *b*,

and bottom board *c*, the cope being in place for ramming up. The dotted line *d* shows the lower line of the pattern,

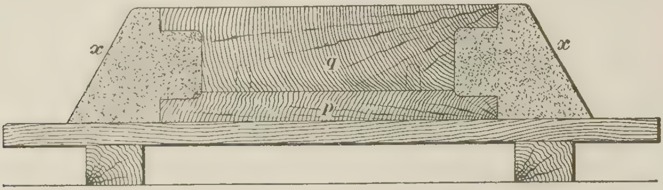


FIG. 11

while *x* is the face line of the pattern and the line of separation between the cope and drag. Fig. 7 is another example which shows the side view of a cope and drag, the lines of the pattern being at *d* and *x*, as in Fig. 6.

6. Three-Part Molds in Three-Part Flasks.—Many patterns are of such a form as to require two or more parting lines. Sheave wheels and wheels having flanges are the most common examples of this class of castings. The most common way of casting such pieces is to have as many parts to the flask as there are parts in the mold. One method of molding and casting a flanged pulley is illustrated in Figs. 8 to 10. The part of the pattern *p* is placed on a follow board with a hole cut in it as shown in Fig. 8 and the drag *b* is placed around it. After this part is rammed up and struck off, the bottom board is then put on, the mold turned over, the pattern section *q* put on,

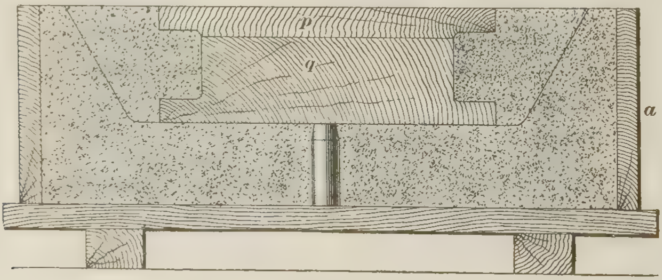


FIG. 12

parting sand sprinkled on the mold, and the cheek or intermediate part *f* of the flask put in place. This part of the mold

is then filled with sand, rammed, and struck off, as shown in Fig. 9. Parting sand is then sprinkled over the joint, the cope put on, the sprue pin located, and the cope rammed. The sprue pin is then removed and the pouring basin *e*, Fig. 10, formed. The cope *a* is lifted off and the part *q* of the pattern drawn from the cheek. The cheek *f* is then lifted and the part *p* of the pattern drawn from the drag. The drag is finished, the cheek put in place, the groove of the pulley vented, the cheek and cope finished, and the cope placed in its position, as shown in Fig. 10. The mold is then complete and ready to be poured.

7. Three-Part Molds in Two-Part Flasks.—A three-part mold may be made in a two-part flask by having an inter-

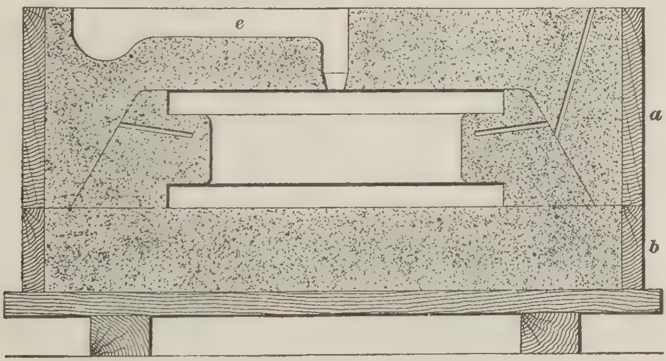


Fig. 13

mediate body of sand between the cope and the drag. This method is illustrated in Figs. 11 to 13, in which the pattern described in Art. 6 is used. The pattern is placed on a mold board and weighted down, after which sand is packed around it to form a joint, as shown at *x*, Fig. 11. The cope *a* is now set on and rammed up, after which the whole is turned over, when it will appear as shown in Fig. 12. Next, the drag *b* is set on and rammed up, after which it is lifted off and the pattern section *p* drawn; the drag is then set back and both parts clamped and rolled over. The cope is next lifted off and the pattern section *q* drawn; the mold is then finished and the cope

set back in place, when the whole will appear as shown in Fig. 13. Parting sand must be used on all the joints.

In venting the cope, it is only necessary to run vents from the parting line with the intermediate section to the top of the cope. The gases will find their way along this parting line and out through the vent.

8. The groove for a pulley casting may also be made with a dry-sand core, as shown in Fig. 14. In this example the

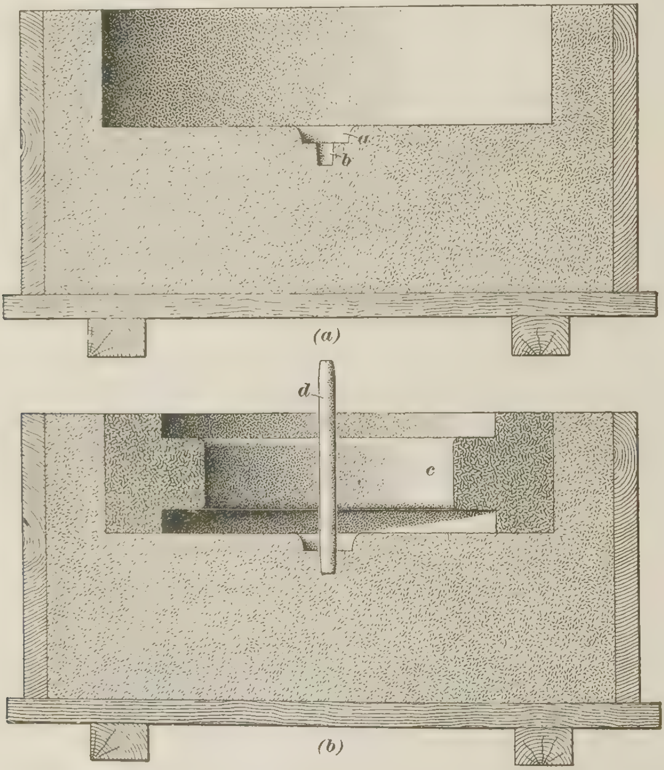


FIG. 14

pulley is also provided with a hub, through the center of which a hole is cored. The green-sand part of the drag is illustrated in Fig. 14 (*a*), in which the form for the end of the hub is shown at *a* and the core print for the center core at *b*. Fig. 14 (*b*)

shows the same mold with the rim core *c* and the center core *d* set.

9. Starting the Joint in Lifting.—The joint in the mold should not only be correctly constructed, but means must also be provided for properly separating the parts, as a good lift often depends on the manner in which the cope is started. Some copes must be started evenly all over the joint, while others part better by starting one side before the other. In light work, many copes are best raised by being rolled up, as in Fig. 15. In rolling up a cope, it may be advisable to have it go upwards and toward the hinge, as shown by the dotted lines in Figs. 15 and 16; or, on the other hand, it may go upwards, first describing an arc away from the hinge and then toward it, as shown by the dotted line in Fig. 17. This movement can be given by arranging the hinges as shown in Figs. 16 and 17, from which it is clear that the matter of having a cope go upwards from or toward the hinged side can be controlled, thereby assisting in getting good lifts. The farther from the joint the center of the hinge is, the more rapid will be the outward or inward movement.

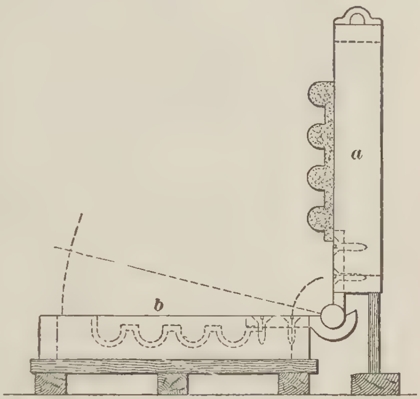


FIG. 15

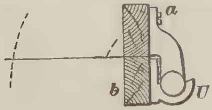


FIG. 16

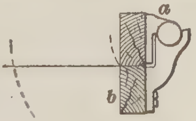


FIG. 17

10. Another form of flask hinge is shown in Fig. 18. The pin is hinged to the cope plate *a*, which is fastened to the cope and passes through the collar *b* on the pin plate *c* of the drag. The drag *d* is rammed on the match plate *e* which may, if necessary, rest on the cope flask to protect the pattern and is rolled

over in the usual way when the cope is put on the other side of the match board. There are two hinge pins on one side of the

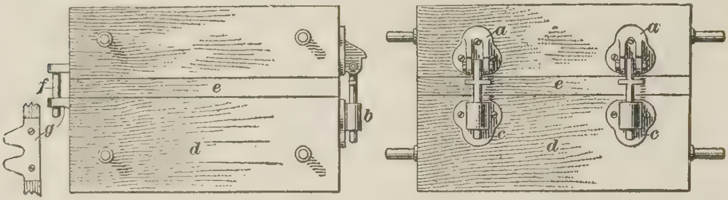


FIG. 18

flask and one steadying pin *f* on the other side. The plate on the drag for the steadying pin has a slotted hole, as shown at *g*.

FOLLOW BOARDS

11. Follow Boards in Forming Joints.—In making the molds for castings that have irregular joints, much time and labor may be saved by using a follow board, or match, that will form the joint; then, when the board is lifted off, parting sand can be sprinkled on and the joint is ready for the cope. In making light work the follow board is often so perfected that it is difficult to see where the joint is on the casting. There are four classes of follow boards: (1) the *wooden* follow board, which is carved out to give the desired shapes to the joints; (2) the *sand-and-composition* follow board; (3) the *plaster-of-Paris* follow board; and (4) what is called the *match board* or

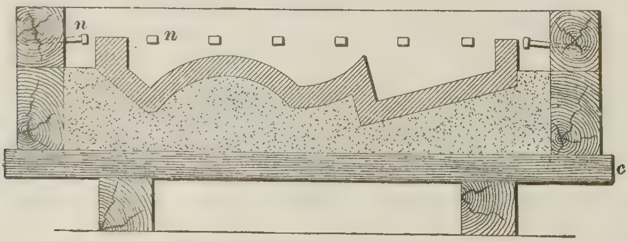


FIG. 19

match plate. The sand and composition follow boards are the ones generally used. Follow boards are sometimes called *odd sides* or *matches*.

12. Sand Follow Boards, or Matches.—The usual method of making sand follow boards is to ram up a drag, harder than usual, and then, after making a good firm joint, set on it a frame having nails driven in at its sides, as shown at *n*, Fig. 19; these nails are driven into the frame to hold the

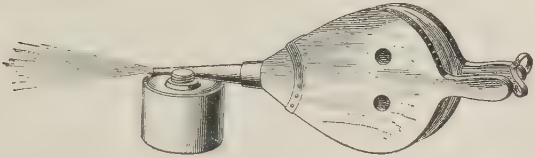


Fig. 20

sand when using the match. When this frame is set on, new molding sand, either tempered with very thick clay wash or made up of 1 part flour to 10 parts sand, is shoveled in and rammed as hard as possible, after which a bottom board like the one shown at *c* is nailed on the bottom of the frame and the frame and board are then lifted off. The surface of the match is now slicked to repair any broken edges or parts that may have stuck down in lifting it off, and a little molasses water is blown over the surface to strengthen the joint. The molasses water used in finishing the joint may be blown from the mouth or from a special sprinkler attached to a pair of bellows, as shown in Fig. 20. Another form of sprinkling device, known as a *blow pot*, is shown in Fig. 21. Fine sprinkling may be done by tilting the pot and blowing with the mouth so that the current of air strikes the liquid as it escapes. When it has been sprinkled, the match should be set aside for a day or two to harden, after which it is ready for use. In light work it is of the utmost importance to preserve the joint edges of sand matches, so as to keep them sharp and unbroken. Sharp edges may be preserved and stiffened with nails driven close together, the heads of the nails being made to come flush with the face of the sand forming the match; even then, the edges may become ragged and cause bad joints. A match made from

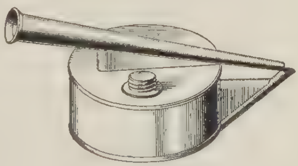


Fig. 21

molding sand, or what is termed a green-sand match, is ready for use as soon as it is made. Most molders give these matches a slight sprinkling every day after the day's work is finished, for they do not work well when in a dry condition.

13. Composition Follow Boards.—In place of ramming the frame, Fig. 19, with molding sand, a composition may be used that will become harder and last longer than the sand match. A composition often used is made up of fine sand, boiled linseed oil, and litharge. The sand should be very dry. Add 1 part of litharge to about 20 parts of sand, mix thoroughly, and then sift the whole through a fine sieve. Temper this mixture with the oil to the same temper as sand intended for ordinary green-sand molding. The mixture is rammed, as one would ram a mold, to a degree of hardness equal to that generally required in copes. After the ramming has been done, the bottom board is screwed to the frame. The match and the drag on which it is made are then rolled over together, the drag carefully lifted away, and the joint finally finished. Before these matches are dry, they are about as fragile as so much dry sand, and require the utmost care in handling, as well as in removing the pattern for the first time. When the match is dry its surface should have a coating of shellac, which will prevent the sand from adhering to the surface. Before putting the match away, its edges and surface should be finished in the same manner as sand matches, using linseed oil instead of molasses.

Molding sand should not be used for these matches, as it weakens them; but some fine-grained sand can be used and almost any sand of fine grain will do. If at any time the corners or edges are found to be broken, they can be mended by patching with beeswax. To form the separation between this match mixture and the sand on which it is rammed, a regular parting sand is used. For very fine work a material known as lycopodium is used. Where the match is too large to lift off the drag, they can both be rolled over, the drag lifted from the match, and the sand then carefully removed from the face of the match.

14. Plaster-of-Paris Matches.—Plaster-of-Paris matches are often used when, on account of the crookedness of the pattern, other classes of matches cannot be made as cheaply,

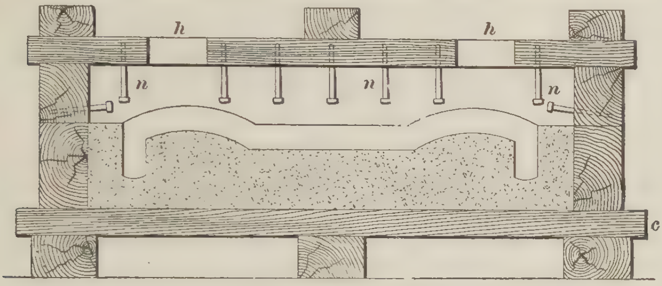


FIG. 22

as perfectly fitted, or kept as true during use. This material gives very hard matches on which to ram, but great care must be taken not to break any of its edges, as, even with care, the working in and out of the pattern is very likely in a short time to cause the edges to become ragged and broken; and no durable method of patching such broken edges has yet been devised. Fig. 22 illustrates the match in process of construction, while Fig. 23 shows it ready for use. In starting to make such a match, the pattern is rammed up in a drag and the joint made as in molding ordinary castings.

15. The joint should be carefully made so as to give it the best possible form, one that will give clean lifts and assist in obtaining finless and true-jointed castings. The patterns are treated with a good coat of oil to prevent the plaster sticking to them. A wooden frame having a bottom board screwed

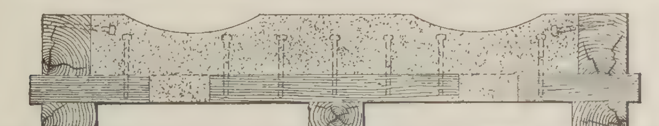


FIG. 23

on is then placed as in Fig. 22; both this frame and the bottom board should have plenty of nails *n* driven in them. In this bottom board are two holes *h* for the purpose of pouring in the

plaster. Before pouring a plaster match, the outside of the joints should be carefully stopped up with clay, or firmly banked up with sand, to prevent leakage. The plaster having been poured in, it is allowed to set until hard; then the drag and match are rolled over together, opened, and the sand removed from the face of the plaster with brush and water. After the face of the board is finished up smooth and the plaster is dry, it is coated with shellac varnish containing lampblack, and when this is dry the board is ready for use.

In using plaster of Paris, the fluidity of the mixture should be regulated by the thickness of the body required. For thin bodies, 2 parts of water to 1 of plaster makes a good proportion, but for general work, 1 part of plaster to 1 part of water will be about right. The pouring holes should be as large as practicable, for in filling thin places or corners, the quicker the match is poured, the better. If a mold has any considerable body, it will shrink so much that more plaster will be required to fill up the mold after it is poured. Before starting to pour a mold, therefore, there should be plenty of water and plaster at hand, to avoid any delay after the pouring has begun. With practice, one can estimate very nearly the amount of mixture required to fill a mold; it should be all mixed before starting to pour, especially in the case of light molds. For thick bodies one may partly fill a mold and then complete the job by a second pouring; but generally speaking, plaster of Paris requires prompt handling.

16. Match Plates, or Match Boards.—Match plates for large patterns are sometimes made with the cope half of the pattern on one plate and the drag half on another, the pattern in each case being fastened to the board. These match boards are each provided with flask irons to fit the flask to be molded on that board. The flask irons are so placed that the cope mold will register with the drag mold and make a casting showing little or no parting line. Match plates for small patterns are made of either wood or metal with the cope half of the pattern on one side and the drag half on the other and with pin holes in the plate to fit the pins on the flask. Fig. 24 shows

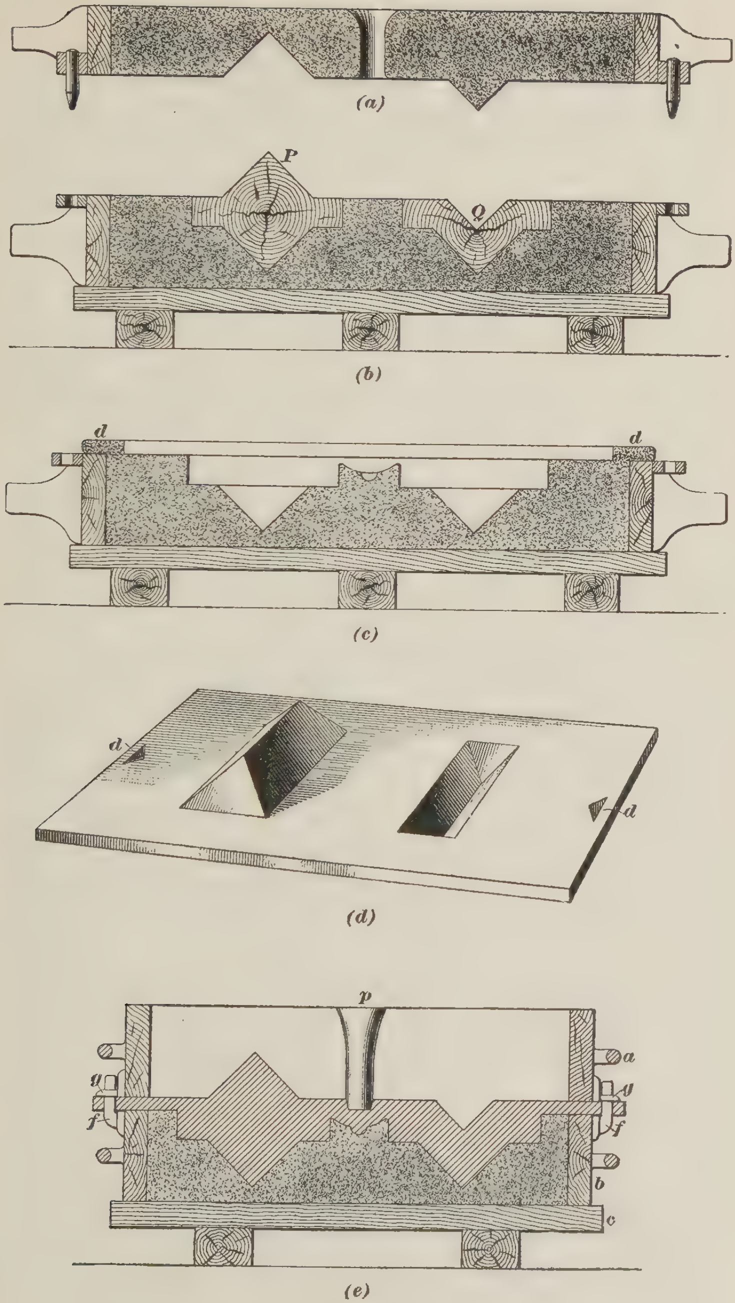


Fig. 24

the method of making a match plate for two patterns, one of which comes wholly below the joint line and the other partly above and partly below it. In (*b*) the drag is shown rammed up and the joint made, *P* and *Q* being the patterns. The cope when rammed up appears as shown in (*a*). The manipulation so far is the same as that required for making a casting from each of the patterns. The plate portion is next molded by banking sand against wooden strips from $\frac{3}{16}$ inch to $\frac{1}{4}$ inch thick. In this way the body of sand *d* in (*c*) is formed. The thickness of this body of sand should be so chosen as to insure the strength of the plate. The gates are cut as though the casting was to be poured through them. The cope is then closed and the mold poured, the casting being the match plate shown in (*d*). Fig. 24 (*e*) shows the drag rammed up, the cope set on, the sprue pin *p* in place, and the cope ready to be rammed up. The ends of this match plate extend beyond the flask and contain holes for the flask pins to fit into, so that the mold may come together properly when closed. These holes are made by drilling and filing to fit the dowel-pins on the drag. This construction will be better understood by reference to (*e*). The drag *b* has pins *f* that are long enough to fit into holes *d* in the match plate and also holes *g* in the lugs of the cope. This arrangement of pins and holes acts as a guide in setting both the cope and the match plate. Should there be any overlapping of joints in the castings produced, the trouble will generally be due to shaky or untrue pins. In making the match plate, as well as in using it, the pins on the flask must be carefully looked after, or properly jointed castings will not be obtained.

17. Wooden matches made by the patternmaker are also used. The match plate or board is of practical use only for castings that have plain outlines and no sharp corners, cores, or projections.

SUPPORTING SAND IN COPE

18. Use of Gaggers and Soldiers.—Gaggers and soldiers are appliances used in combination with flasks and cross-bars to enable the molder to lift and suspend bodies of

sand. This definition will be better understood by reference to Fig. 25, which represents a cope 16 inches square by 5 inches deep. If this cope were rammed full of good and properly

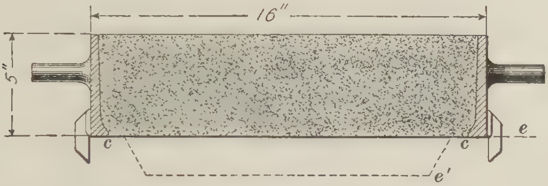


Fig. 25

tempered sand, having its joint level with the bottom edge of the cope at *e*, the sand would lift and stay suspended. Instead of the joint being level with *e*, it may be desirable to have the cope sand project down into the drag, as shown by the dotted line at *e'*. Where the sand extends more than $\frac{3}{4}$ inch below the level at *e*, it might not lift with the cope; or if it did, it could not be safely suspended without the use of gaggers or soldiers.

The volume of sand that can be carried without special securing varies with the condition of the sand. A coarse sand will not hold as well as a fine sand. A body of sand 16 inches square and level with the lower edge of the cope, as at *e*, Fig. 25, is about as large a body as can be suspended without the use of cross-bars. Even with a body 16 inches square, it is sometimes necessary to have grooves along the sides of the flask or else projections like *c*, as without one or the other the sand will be liable to slide out of the cope. While 16 inches square is given as being the largest area of sand that can be safely suspended, even that area cannot be lifted in all cases.

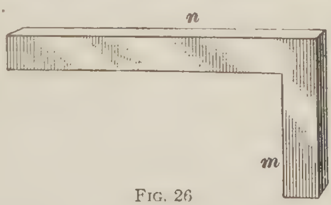


Fig. 26

19. Making Gaggers. Gaggers are made of cast or wrought iron. Fig. 26 shows the form generally used. They can be made of either square or round iron, and are usually about 4 inches long at the toe *m*, with the shank *n* from 5 inches to 20 inches or more in length,

according to requirements, and from $\frac{3}{8}$ inch to $\frac{1}{2}$ inch in diameter or square. In some shops wrought-iron gaggers are used

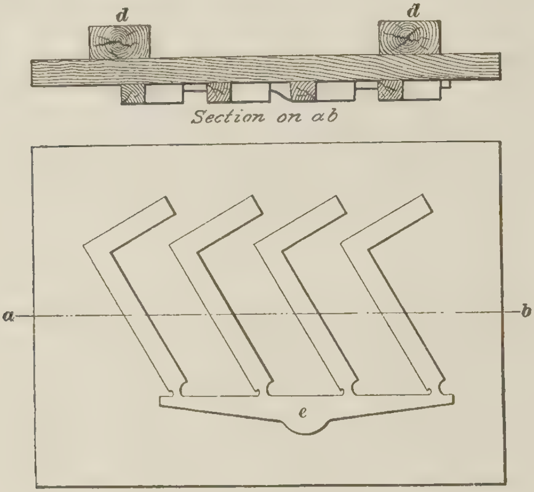


Fig. 27

almost exclusively; while in others, cast-iron ones have the preference, as they will not spring, are cheaper to make, and can be readily broken off to any desired length when shorter ones cannot be found.

20. Wrought-iron gaggers are useful in work where the toe must be bent to suit slanting surfaces and joints. In some foundries objection is made to breaking cast-iron gaggers, and to avoid breaking them they are left sticking out of the cope. Gaggers sticking up in this way are liable to be hit accidentally after the cope is closed and the loss of the casting may result. It is bad practice to leave gaggers standing above the surface of the cope. Cast-iron gaggers can be made to good advantage in open sand by having from four

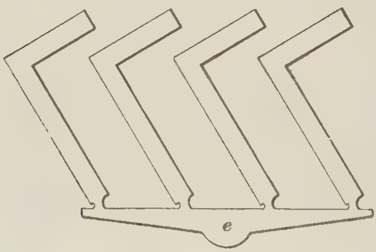


Fig. 28

to twelve patterns on a board, as shown in Fig. 27, and pressing the board into a level bed of soft sand by pounding on the battens *d* with a light sledge. When the gaggers are cast, they appear as shown in Fig. 28; they are easily knocked off the runner *e* with a hammer. Wrought-iron gaggers are usually made

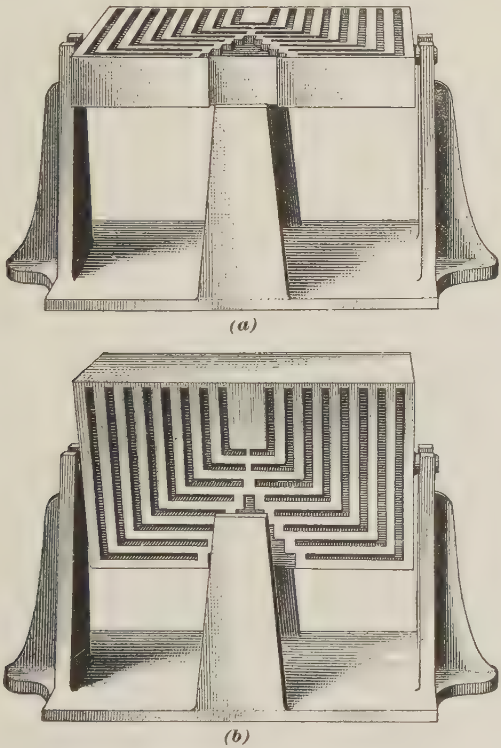


Fig. 29

by cutting straight bar iron into the required lengths and bending the toe *m*, Fig. 26, in a vise or over an anvil.

21. Cast-iron gaggers may be made very rapidly by the use of a chill mold, as shown in Fig. 29 (*a*) and (*b*). The illustrations show a gagger mold that can be used almost an unlimited number of times during the heat. It is swung on a cast-iron bedplate, supported by two trunnions that allow the mold

to be turned over, as shown in (*b*), which illustrates the process of turning it over for the purpose of dumping the gaggers. The metal is poured on the mold, which is then turned over, striking a stop when upside down so as to jar the gaggers loose and allow them to fall out. Both sides of the plate contain molds for gaggers, so that as soon as the plate is turned over the molder can pour the second set of molds full. This process can be repeated until the mold gets hot, when it must be allowed to cool off for a time. Gagger molds are sometimes made hollow and cooling water is circulated through them, thus keeping them cool and allowing them to be used continuously.

22. Making Soldiers.—Soldiers are strips of wood. They can be made by cutting a piece of rough straight-grained board, sawed to any desired length, into strips of any desired size. They range in size from a narrow strip to one 8 inches wide. Lath make good soldiers. Often these soldiers will be nailed to the sides of cross-bars, so as to assist in lifting deep bodies of sand. The soldiers, if well sustained between the cross-bars by nailing them or by ramming them firmly will lift larger bodies of sand than if gaggers were used over the same area. In using soldiers, they must not be placed too near the surface of the casting, where there might be danger of the iron breaking the sand away from their surfaces, for if this occurred the steam and gas from the wood would cause the mold to blow and spoil the casting. Then again, if soldiers are to remain bedded in the sand for more than a few hours, they should be well soaked in water before being placed in position, for if they swell in the mold, they may cause bad castings.

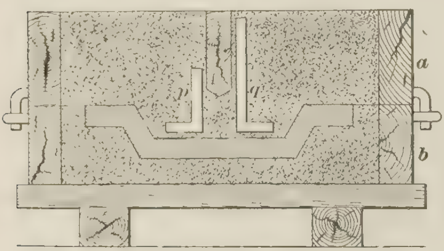


FIG. 30

23. Setting Gaggers.—The main thing to be kept in mind when setting gaggers is that, bulk for bulk, a gagger is

about $4\frac{1}{2}$ times as heavy as rammed sand. Gaggers are sometimes used to aid in lifting bodies of sand that would have a better chance of being lifted were the gaggers omitted; this statement will be better understood by reference to Fig. 30, in which a body of sand about 3 inches deep is to be lifted. Gaggers set as at *p* will do more injury than good; to be of any service they should be so long that at least two-thirds of their length will be between the cross-bars, as at *q*. Then, again, where gaggers are expected to lift a heavy body of sand, not only should they come up well between the cross-bars or in the cope, but the sand should be firmly peened and rammed between them.

24. Cross-Bars.—In putting bars into ordinary copes, a space of from 5 to 6 inches between bars will answer for plain

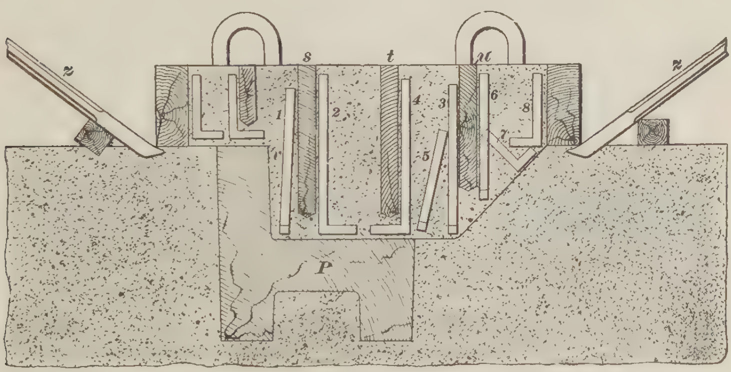


FIG. 31

work; but for copes that have bars projecting into deep recesses in the drag, or that have them cut to permit projections to extend into the cope, different spacing and a different system of barring are often necessary. At *s*, *t*, and *u*, Fig. 31, is shown an objectionable method of setting cross-bars in the cope used for making a long casting of the general cross-section shown at *P*. One objection is that the flat side of a cross-bar is placed parallel with the flat face of the pattern, leaving a poorly supported, thin, flat body of sand *v*. In ramming sand in such narrow pockets as at *v*, good judgment must be exercised; if

the sand is rammed too hard, the gases will not escape freely and scabbing or blowing is likely to result. Another objection to the method shown in Fig. 31 is that where it is necessary to roll the cope over, the thin flat cake of sand is liable to drop off unless securely rodded, which involves having straight rods of round iron coming from the face up between the bars. Bars used for lifting sand out of pockets or for carrying hubs or other projections should be arranged so as to have a considerable body of sand around them. The dangers due to hard ramming, or lack of freedom in venting are not only lessened, but more room is given for ramming up and seeing what is being done when setting gaggers, etc. Another objection to using

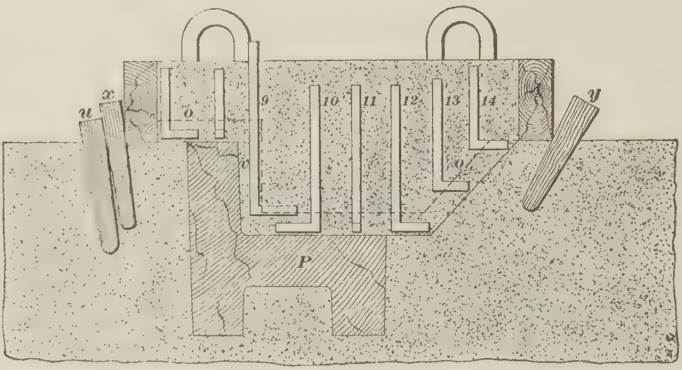


Fig. 32

bars as at *s*, *t*, and *u* is that the gaggers cannot be set very readily or firmly and the danger of a drop-out is greatly increased. For work of the character here shown, the bars should be set across the mold, as indicated by the dotted outline *0 0* in Fig. 32. The positions of gaggers *1*, *2*, *5*, *7*, and *9*, Figs. 31 and 32, show lack of judgment. The sand at *7* would be more likely to lift if the gagger were not used, as its length is only about equal to the thickness of the body of sand to be lifted, and iron, as already explained, is a great deal heavier than sand. If bars could not be placed as at *0 0*, Fig. 32, and it were necessary to set a gagger as at *1*, Fig. 31, it would be better to keep it higher and reverse the toe of gagger *2*, bringing the toe or point under the bar toward the face of the pattern.

The positions of gaggers *11*, *12*, *13*, and *14*, Fig. 32, in connection with the bars at *0 0*, represent good practice. Gagger *10* might have its toe set very close to the face of the pattern at *v*, while *9* might be set between *10* and *11*, with its toe parallel to *11*. If the cope is to be rolled over, more gaggers, *13* and *14*, should be used as the height of the ramming increases. The points of gaggers against the surfaces of flat bodies of sand cannot do the harm that gaggers can when set as at *1* and *9*. The latter give poor support and produce soft spots in the mold.

25. Staking and Lifting Cope.—Fig. 32 also shows right and wrong methods for staking copes that are used over bedded-in patterns. Stakes should be driven almost parallel to the side of the cope, as illustrated at *x*; it is not a good plan to drive them at a considerable angle, as shown at *y*. A stake driven in this manner is liable to cause poor lifts and imperfect castings, because of the great angle it makes with the surface of the floor. In staking flasks for ordinary work, at least two-thirds of the length of the stake should be driven into the ground. Sometimes, to insure greater certainty in large work, it is best to drive one stake behind another, as illustrated by *u* and *x*. To assist in the lifting of such deep copes as are shown in Figs. 31 and 32, iron starting bars can sometimes be used, as shown at *z*, Fig. 31. It is important that the cope be started properly; for if it is started so as to raise one side before the other, or if it is started with a jerk, the most careful ramming and use of gaggers will be of little avail in giving a good lift. When two or more men are required to lift the cope, it is often a good plan to first raise it 1 to 2 inches by raising each corner alternately from $\frac{1}{8}$ to $\frac{1}{4}$ inch and inserting a wedge to hold up the corner as it is lifted, or it may be advisable to raise one side of a cope at a time; the distance can usually be increased at each succeeding lift.

FINISHING THE MOLD

26. Work Required After Drawing Pattern.—As a rule, all molds require more or less finishing after the pattern has been drawn, bench-work castings requiring the least of any.

The majority of light-work patterns are so finely made and gated that the mold may be closed as soon as the pattern is drawn, no finishing whatever being required; in heavy work, however, the reverse is usually true. It some cases it may take longer to finish a mold than it takes to ram it. This fact may be due to the intricacy of the design, to bad work in drawing the pattern, or to the manner in which the mold was rammed up.

27. Care and Skill in Ramming.—Two molders may ram up the same pattern in the same flask, and yet one may take twice as long to finish the mold as the other. As a rule, the greater the care, skill, and time bestowed on ramming, the less time is required on finishing; the skilled and careful workman, generally speaking, so rams his mold as to require the least time in finishing.

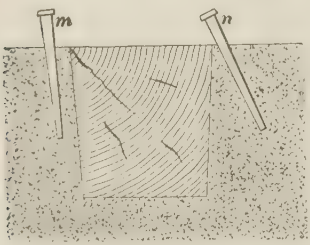


Fig. 33

In many heavy-work molds, the insertion of a nail or rod at the corners and flanges when ramming will render them less liable to start or break when drawing the pattern; and there are but few such molds in which care in ramming will not prevent them from having soft places that require to be patched. In some cases, the soft places that occur from careless ramming may be so extensive as to cause large portions of the mold to break and fall while the pattern is being drawn. In the ramming of copes especially there is an opportunity to save subsequent labor in finishing. Some molders use so little skill and care in ramming the cope that when it is lifted off the sand will be soft under all the cross-bars. Where this occurs, the soft places must be pressed down solidly with the fingers, sand filled in firmly by hand, and rubbed off level with the rest of the mold by using a finishing block or straightedge before the surface is ready to be slicked with the trowel. All this extra work can be avoided by careful ramming. When a cope is poorly rammed, the sand under the cross-bars may have to be worked

over to make it solid. A cope so treated rarely has as good and true a surface as would otherwise be the case.

28. Nails and Rods at Joints and Corners.—A judicious use of nails or rods in ramming and finishing molds may prevent many castings from being defective. The nails may, however, be used too freely or improperly. A nail should not be used as shown at *m*, Fig. 33, as when driven in this manner, it only adds weight to the edge of the mold, instead of giving it support to keep it from dropping. The proper way of using such nails or rods is shown at *n*. Here the nail is driven in such a way as to take it away from the face of the pattern

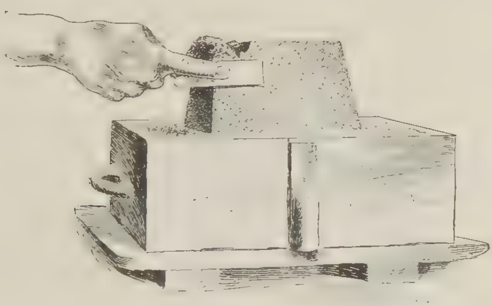


FIG. 34

into the body of the sand, where it can have a firm hold and assist in keeping the edge from dropping.

29. Patching the Mold.—Often the mold is more or less broken in drawing the pattern. Whenever practicable the mold should be mended with the hand and then smoothed off with a finishing block or straightedge to as nearly the proper form as possible before a trowel or other finishing tool is used Many molders patch such places with a trowel; but when one takes sand on a trowel and presses it on to the mold, he gives the face of the patched part a smooth surface, with which the next trowel of sand will not unite as well as when the broken parts are built up by using only the hands. The objection to patching with a trowel is that the patched part may be easily loosened and is liable to drop if the cope is slightly jarred; or

it may be washed off by the friction of the metal when the mold is poured. Fig. 34 shows how the broken corner of a mold is patched with a trowel, while Fig. 35 shows the hand being used to get the part in proper form before the trowel is used. Patching of this kind may sometimes be done by placing pieces of straight boards against the sides of the mold, thus getting a perfect outline, and then pressing sand down on the mold.

30. Swabbing Broken Corners.—Many molders before starting to patch a broken mold freely wet the surface with water, thinking thereby to make the sand stick better to the broken body. Unless the broken surface is drier than the rest of the mold, it should not be moistened. If it should require

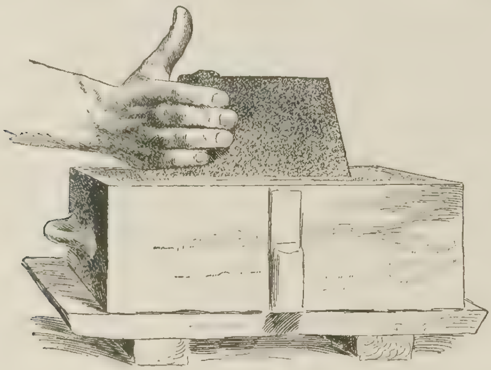


FIG. 35

moistening, however, the mouth or one of the spraying devices shown in Figs. 20 and 21 should be used; for when the water is put on with a swab or sponge, it is liable to make the surface of the broken part too wet and thus may do more harm than good.

31. Moisture in Molds.—In tempering green sand, a certain degree of moisture is given to it, and when this is too great, the volume of steam created by the hot metal in the mold, during the pouring, may become dangerous. The sand will permit a certain amount of steam to pass through it without harm; but when the body of the sand is too wet and molten

metal is poured into the mold, the sand is heated to a temperature sufficiently high to change the water to steam and this steam will be liberated in the line of least resistance. If the wet portion of the mold has been well vented, the steam may pass off through the sand; but the line of least resistance will more likely be through the heated metal. In this case the steam will probably have force enough to raise partly, at least, the body of sand that is in contact with the metal, when lumps or scabs on the casting may be expected, making it defective. Or so much steam may be created that the mold will be made to blow; that is, the steam will be formed so fast that it cannot escape through the vents and will rush out through the sprues and risers, scattering the molten metal. A broken part of the mold may generally be mended without first wetting it; after the patching is completed, the surface of the finished part may be wet with a swab, in some cases quite heavily, without injurious results from steam, since the steam will not have to pass through a thick body of sand, in order to escape. Being created at the surface, the portion of steam that does not pass off through the sand has only the iron to pass through. The casting may thus be caused to blow to some extent, as would be the case if the steam had come from the lower parts of the mold; but if the blowing is not too great, the casting will not be injured.

32. An illustration of what is to be expected from steam confined under the surface of the mold is shown in the fact that one can cover the surface of a body of liquid metal with water without any injurious consequences, the reason being that the steam is created on top of the iron and has simply to pass off into the atmosphere in being liberated. Let one try, however, to place the same body of water in the bottom of a ladle and then pour liquid metal in on top of the water; the result will be an explosion that will drive all the iron out of the ladle and possibly seriously burn those near by. Dampness can only exist with safety so long as it is above the metal; if it occurs underneath the metal, serious results may be expected. If the molder will bear this principle in mind when swabbing any

part of a mold, he will have very little trouble with scabs or blowing as a result of an excess of moisture.

Another evil resulting from the use of too much water in finishing a mold lies in the hardening of the metal at the point of extra dampness. The edges of castings can be made so hard by extra dampness in the sand at such points that a file will not cut them. Another effect of excessive dampness is to give the iron an extra amount of combined carbon at such points; this alteration of its physical nature may cause a casting to crack when cooling, or break in pieces when put into use.

Fig. 36

33. The Venting of Patched and Sharp Bodies of Sand.—It is always well to vent patched parts of a mold with a $\frac{1}{16}$-inch vent wire, for usually the patched sand will be harder and damper than the rest of the mold. Again, in many large molds having corners, projections, etc., it is a good plan to pass a fine wire from the face downwards into the body of the mold to a depth of from 4 to 6 inches. These fine-wire vents will provide a means of escape for the gases to the larger vents and if made about 1 inch apart over the surface most likely to scab, this evil will be avoided. Many molders make a practice of venting almost every sharp corner or projection in large molds, and although this takes time, yet it pays in the end, for it is seldom that any delicate portion of molds so vented gives scabbed castings. To prevent such fine venting breaking the surface of the molds, the vent wire is run through the

opening between two fingers, as shown in Fig. 36. The tops of the fine vent holes are stopped up by pressing the fingers or palm of the hand over them and then going over the holes with a little finely sifted sand, rubbing it into them with the hand; after this, the surface is neatly slicked and then dampened lightly with a swab, or sprayed. The success of some molders in getting large castings free from scabs, etc. is due in part to their habit of using the fine vent wire at corners when finishing the molds.

34. Using the Trowel.—Considerable skill is required in handling a trowel properly. When one first uses a trowel,

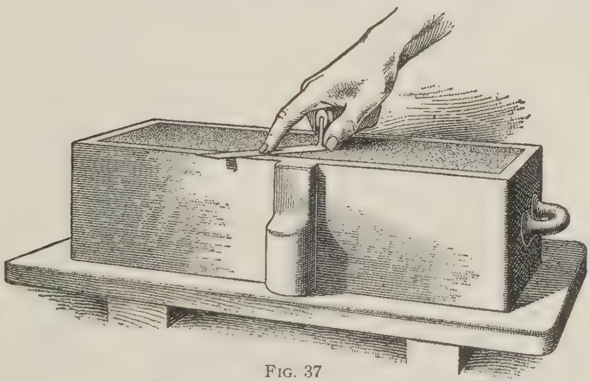


FIG. 37

he is liable to dig into the sand and do more harm by loosening the sand than he does good by pressing it down to a solid smooth surface. The trowel should never be kept flat on the body being slicked, as in Fig. 37. One edge should be raised slightly, as at *d*, Fig. 38; it is here, however, elevated an excessive amount for the purpose of illustrating the idea more clearly. The trowel should have its forward edge raised only about $\frac{1}{16}$ inch, this distance being just enough to keep it from digging into the sand and yet leave a smooth flat surface on the sand. An expert may, in many cases, slick green-sand surfaces with the whole flat surface of the trowel bearing on the sand.

In handling a trowel, the first finger should project as far on the blade as convenient, so as to give a pressure to the

blade, as shown in Fig. 37; a novice will usually grasp a trowel by the handle, as shown in *e*, Fig. 38.

A facing of dry blacking or silver-lead dust should rarely be slicked on the surface of a mold with the flat of a trowel; for the blacking may stick to the trowel, and, even if it does not stick, it is liable to loosen in such a manner as to lift when the mold is being poured and cause what are called *blacking scabs* to appear on the casting.

35. Using Slicking Tools.—When slicking wet blacking on cores or molds in skin-dried, dry-sand, or loam work, the trowel must be kept tilted. If at any time the flat face of the trowel or any other finishing tool touches the wet blacking, it will stick to it. Not only must the finishing tool be tilted,

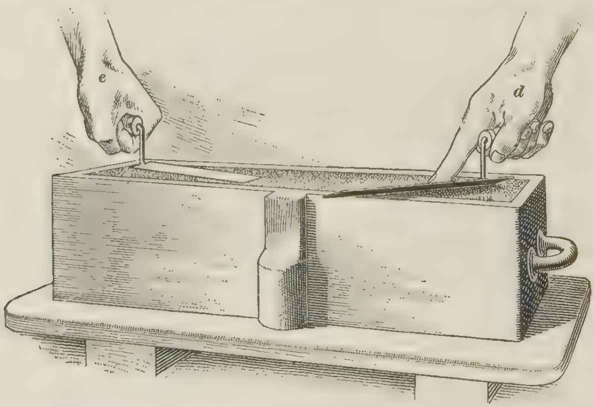


FIG. 38

but it must be kept in motion, for if stationary for an instant, the wet blacking will stick to it. Considerable skill is required in slicking wet blacking, and much experience is necessary before one can handle finishing tools in such a manner as not to start the blacking, which would cause blacking scabs on the casting. Some wet blackings are so difficult to slick that it is necessary to keep constantly dipping the tools in water, in order that they may slide more easily over the blackened surface.

36. Other Finishing Tools.—A molder should have a good set of molding tools. Some shops demand that a molder

be well equipped with tools; in fact, they often go so far as to require the molders to have tools that will fit nearly every variation in the shapes of edges and corners that may exist in their patterns, and if these shapes are out of the ordinary line manufactured by regular toolmakers, the shops will have the special tools made.

The trowels, lifters, and double-enders are usually constructed of steel, while the other tools are often made of cast iron and brass. Brass tools will slick wet blacking better than those made of iron or steel, although if steel tools are nicely made and finished, many molders can do better work with them than with those made of brass. Figs. 37 to 39 show the ordinary finishing tools which can be obtained in different sizes from dealers. A tool box especially designed to hold tools in such a manner that any one of them can be readily found is very desirable, and the tools should always be clean and in good order, ready for use. The names of the tools shown in

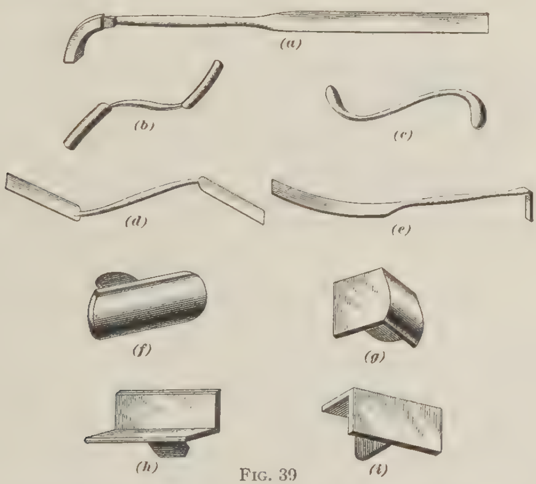


FIG. 39

Fig. 39 are as follows: (*a*), flange and lifter; (*b*) flute; (*c*), bead; (*d*), double square; (*e*), Yankee No. 1; (*f*), pipe slick; (*g*), half-round corner; (*h*), inside square corner; (*i*), square corner.

37. Slicking and Printing Dry Blacking.—After the surface of a mold has been finished, it is often necessary to black

it, so that the casting will have a smooth surface and will peel better from the sand. The blacking may be dusted on or rubbed on with the hand and then slicked down solidly with the same tools which were used in finishing the surface of the sand. For heavy castings, it is best to rub on the blacking with the hand; especially is this necessary when putting it on the sides of molds and copes that cannot be rolled over. In a great variety of work, the blacking can be shaken out of a cheese cloth, or other thin cotton-cloth bag, as shown in Fig. 40; or it can be scattered by the hand in the same way that parting sand is spread. After a mold has been coated with dry blacking, it should be slicked without delay, as the blacking is likely to absorb the moisture from the sand. With some blackings it will then be difficult to slick them so that they will not stick to the trowel, and the result will be a badly finished mold that may cause blacking scabs. Where trouble is caused by the blacking sticking to the tool, it is best to dust on a light coat of charcoal over the top of the heavy, sticky blacking. Charcoal dust is very light and is slow to absorb moisture; these qualities make it an excellent material to aid in the slicking of sticky grades of blacking. Where charcoal has been used, bellows are necessary to blow off all the dust that does not adhere to the surface of the mold; if this is not done the loose dust will run before the metal when the mold is poured and gather in lumps. In fact, where it is desirable to have clean, sound castings, it does no harm, whatever the grade of blacking may be, to use the bellows to blow off the dust, provided the face of the mold is not broken by the force of the blast.

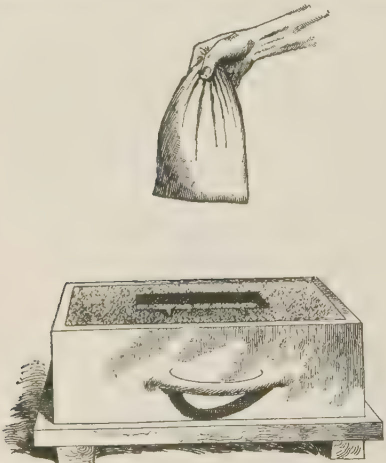


FIG. 40

38. It is chiefly in medium-weight and heavy castings that it is found necessary to slick dry blackings. In light work, another plan called *printing back*, is largely followed. This process consists in shaking the blacking from a bag evenly over the whole surface of the mold and then setting the pattern back carefully into the mold; the pattern is then rapped down lightly over the whole of its surface and in this way pressed into the blacking dust. It is again rapped lightly to loosen it in the mold and then drawn. If these directions have been closely followed, the loose blacking dust will have been pressed down solidly on the face of the mold and will give form to the most delicate imprint of the pattern. In printing patterns, the molder generally has at least two bags: one holding a heavy blacking which he will shake on first, the thickness of this first coat being sufficient to cover the face of the mold only about $\frac{1}{64}$ inch; the other bag containing charcoal dust, or some other light grade of a specially prepared blacking. As soon as the dust from the first bag has settled, the second bag will be used, after which the pattern is printed back, as described. In this process, it is most important that the pattern should be perfectly dry; for if there is the least moisture about it, the blacking will stick to it when it is drawn from the mold. After a pattern has been imprinted, bellows are often used to blow off any blacking dust that may not have been firmly pressed on to the surface of the mold.

SKIN-DRIED MOLDS

39. Many large castings that it was formerly thought impossible to make except in dry-sand or loam molds are now made in green-sand molds with skin-dried surfaces. Skin drying is also practiced with lighter work for the purpose of giving green-sand castings the surface and color of dry-sand ones. It may be advisable to skin-dry some molds because of the nature of the sand used; the sand may contain too much clay, or it may be of such a character that it would not otherwise withstand the heat and wash of the metal. The purpose of skin drying is to give green-sand molds a hard surface, devoid of moisture as far as possible and similar to the hard and dry

surface found in dry-sand and loam molds. For this purpose special physical characteristics are required in the sand that is used for the facing, as common heap sand can be used only for the backing.

40. The facing sand should be of a loamy open nature, hardening only when heated, and also sufficiently porous to permit the metal to lie against its surface without bubbling or boiling. When unable to obtain the right grade of sand for making facing, the ordinary grades may be used if mixed with flour, molasses water, or clay wash. When flour is used, the usual proportions are 1 part of flour to from 20 to 30 parts of sand, according to the nature of the latter. In this case, care must be taken in drying the mold, for if the heat is great enough to burn the flour, it will cause the surface of the mold to crumble. The molasses water or clay wash may in some cases be used for wetting sand that has been mixed with flour, or the flour may be omitted and the sand sufficiently strengthened by the aid of the washes. Some sands, because of their closeness, should be mixed with a sharp sand. Some localities possess molding sand naturally adapted to skin drying, while others do not, and therefore in the latter more or less *doctoring* will be necessary to make the sand serviceable. The thickness of the facing used against the pattern generally ranges from 1 to 2 inches. After the facing sand has been banked against the pattern, common heap sand is used for a backing, and the mold rammed in the manner generally followed in green-sand work.

The facing for skin-dried molds is, as a general rule, used a little damper than facings would be for common green-sand work.

41. Finishing a Skin-Dried Mold.—In finishing the joints of skin-dried molds, it is essential that they be shaved as shown at *i*, Fig. 41, so as to prevent them from crushing at the edges when the copes are closed, for the least pressure on the joint at the edge of such a mold may readily cause a crush. No class of molds requires more delicacy in handling, for the surface is a dry crust only about ½ inch thick that has but little

union with the body of the mold and may easily be separated from it by any jarring. Some molders will not trust to the nails for holding the portions of the mold surrounding the gates, but instead make cores the shape of that part of the mold and ram them up with the pattern. This method is best for preventing skin-dried molds from cutting at the gates.

42. After the mold has been made and its surface nailed over, as just described, it is finished by wetting the entire surface with molasses water. This wetting is done lightly by means of a camel's-hair or other soft brush. After the surface has been moistened, it is slicked up with finishing tools, as in finish-

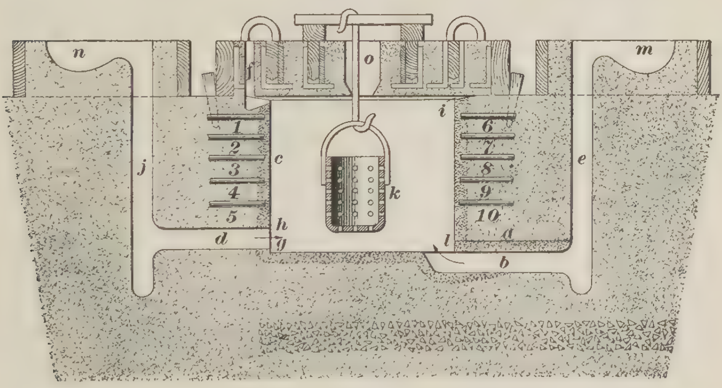


Fig. 41

ing any green-sand mold. Where molds are very large, they are moistened and finished in sections, for if all the surface of a large mold were moistened at one time, portions of it would be too dry to finish well by the time the molder reached them. When more than one molder is working on a job, this precaution may not be necessary. The mold having been slicked with the finishing tools, the next proceeding is to blacken its surface, which may be done in one of two ways. One way is to black the mold in the same manner that a dry-sand or loam mold is blackened; the other is to rub the blacking on dry in the dust form and then, after slicking it as described in Art. **35**, to moisten the surface heavily with molasses water, applying the

liquid with a soft brush. Rubbing the blacking dust on is necessary only on the sides of the mold, as a bag can be used to shake the dust on the bottom. These two methods of blacking may often be used to advantage on the same mold. The plan of rubbing the blacking on dry and then going over it with the molasses water does not dampen the surface as much as when it is blackened with an all-wet blacking, as in the case of a dry-sand or loam mold. These two plans of blacking will sometimes work well together because in skin-drying the mold with fire-pans or sheet plates, some parts will receive more heat than others.

43. By exercising care and judgment in dampening the sand and in blacking, all parts of the mold may become dry at about the same time; if the work is done in such a way that one part dries before the others, it may burn. The surface should be blackened as smoothly as possible, so as to avoid the necessity of much slicking. By slicking the wet blacking, a smoother casting may be produced; but unless it is carefully and skilfully done, there is danger of the slicking causing scabs. The blacking can be put on thin enough not to be streaked, and with care in using a camel's-hair brush, no streaks need be shown, so that the castings can be made nearly as smooth as if the blacking were slicked and the danger caused by slicking can be avoided.

44. Drying a Skin-Dried Mold.—In drying these molds, considerable judgment is required, for a scheme that will work well with one mold may not answer for another. That method must be adopted which is best suited for the work in hand. For example, some molds, such as those for anvil blocks, etc., may be dried by hanging a fire-kettle in them as shown at *k*, Fig. 41, where the cope is shown being dried above the drag. Sometimes the mold may be of such a form that a flat or square pan is required instead of the cylindrical kettle here shown; and with some molds this plan will not answer at all, because they are so shaped that kettles or pans cannot be used in them. These molds may be of such a form that their surfaces can be dried by laying sheet-iron plates, perforated with small holes, over

them and placing a fire on the plates; but this is a plan rarely used where kettles or pans can be employed.

In cases where the sides of molds are very deep and very heavy or deep copes are used, it is often well to ram up $\frac{1}{2}$- to $\frac{3}{4}$-inch rods as at Nos. *1* to *10*, Fig. 41. In this illustration the pouring basins are shown at m and n, the upright pouring gates at e and j, the inlet gates at b and d, the riser at f, the feeder at o, the fire-kettle at k, the dried crust at c, the inlets at h and l, and the inlet-gate top core at a.

45. Where the copes are skin-dried, they should, as a general rule, be very closely gaggered. With some grades of sand, the surface should have nails between all the gaggers, with the heads coming even with the face of the mold and covered only with the blacking; for if this precaution is not taken, the dried crust on the surface of the mold may drop off easily. Not only is this method practiced with copes, but in some cases molders will nail the side of drags that are over 6 inches deep as a protection against the dried crust falling away from its green backing. The gates and portions of the mold where the metal first enters are generally the parts that should be well nailed, for in skin-dried molds, if the surface once becomes broken, the crust soon washes away, after which the material offers no greater resistance to the rushing metal than would so much dry dust.

46. The fuel commonly used for skin drying is charcoal; the fire should be mild and steady, especially at the start, since too strong a fire is apt to blister the face of the mold. Sometimes the cope and the drag may be dried together, by having the cope propped up clear of the drag and then heating between them by means of fire on perforated plates or in pans. Again, the mold may be so constructed as to permit it to be closed while being dried, the riser and gates being left open to let out the steam, as shown in Fig. 41.

Gas may be used for drying molds. The gas is conveyed to the mold in a rubber hose having a piece of gas pipe in the end and then burned against the face of the mold.

47. Green-sand cores or bodies forming the interior of molds are generally skin-dried by placing them in an oven and keeping

the heat mild and uniform. To ascertain whether a mold or core is skin-dried deep enough, it may be tested by cutting a small hole in the surface or by pressing the surface with the fingers. The most difficult places to dry by means of kettles or pans are the lower corners of a mold, as shown at *g*, Fig. 41. The sides of some molds might be baked and the binding material burned to ashes before these corners would be dried. After a kettle or pan fire has been taken out, hot coals or hot irons must often be placed around in the corners to get them dry. The advantage of gas or hot air is here apparent, as by either of them the heat can be directed to any given spot until it is thoroughly dried.

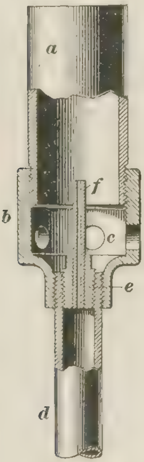


FIG. 42

Any one wishing to acquire skill in skin-drying molds should begin on a small scale, as he is liable to make many mistakes at the start.

48. Burners for Drying Molds.—A good plan to follow when drying molds by means of gas is to substitute a Bunsen burner for the pipe. The objection to using an open pipe burner in the foundry is that usually a $\frac{1}{8}$- or $\frac{1}{4}$-inch pipe is used, which is not only wasteful of gas, but its flame deposits such a heavy coating of soot on the face of the mold that the drying is not accomplished as fast or as economically as it should be with the amount of gas used.

The Bunsen burner illustrated in Fig. 42 has been designed and used for this class of work; it is also well suited for any work requiring a gas heater. As ordinarily constructed, the burner consists of a piece of $\frac{1}{2}$-inch pipe *a*, 6 inches long, threaded at one end and screwed into a reducer *b*. The reducer has five $\frac{1}{4}$-inch holes *c* drilled into it to admit air. More holes may be drilled if required; and if too much air is being furnished, some of them may be plugged up with wood, or, better, by tapping the extra ones and putting in $\frac{5}{16}$-inch screws. A $\frac{1}{4}$-inch pipe *d*, about 2 feet long, is threaded on one end and closed with a plug *e* driven or screwed into it. A hole is drilled lengthwise through the plug *e* and a tube *f* of $\frac{1}{16}$-inch bore fastened into it.

This $\frac{1}{16}$-inch hole furnishes the right proportion of gas to the burner. The tube *f* should extend at least $\frac{1}{4}$ inch past the holes *c* through which air enters. The lower end of the pipe *d* is connected to the gas-supply pipe by means of a rubber hose. When constructed in this manner, the burner may be used upside down or in any other position. The air and gas mix in the pipe *a* and the gas is completely consumed, because there is plenty of air mixed with it before it begins to burn. It gives no light, the flame being blue, but a great deal of heat.

49. An oil-burning outfit is shown in Fig. 43. In principle, this burner is the same as the common blow torch, but it is of

Fig. 43

larger size. In the ordinary blow torch, the burner is fastened to the top of the tank that holds the oil. This oil tank usually holds no more than 3 quarts and the torch is therefore easily carried around. In the style of torch shown, the tank *a* may have a capacity of several gallons, and consequently be rather cumbersome to carry around, and the burner *b* is therefore made separate from the tank, and is connected to it by a rubber

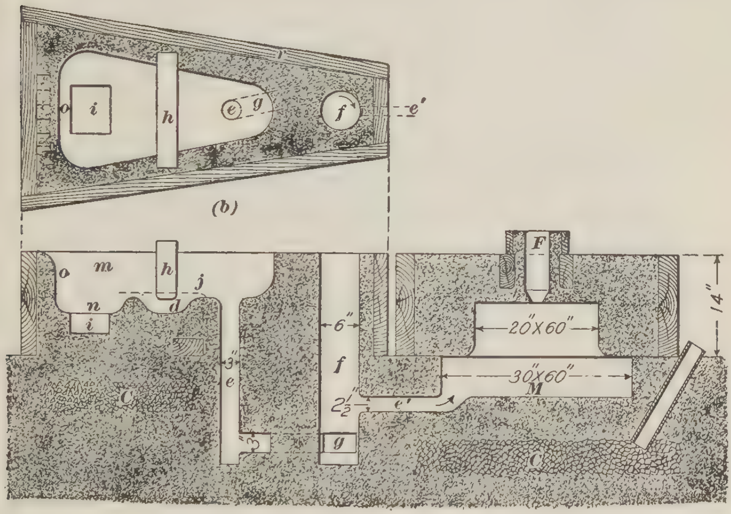
hose. The oil is forced to the burner by air pressure in the tank *a*. The air pressure is produced by a hand pump inside the tank, which is operated by the handle shown at *c* and the pressure is shown by the gauge *d*. Valves are provided at *e* and *f* to control the flow of oil and the tank is furnished with handles *g* by which it may be moved when necessary.

50. Gating a Skin-Dried Mold.—In gating skin-dried molds, the method that will cause the least friction between the flowing metal and the surface of the mold is, as a rule, the best one to adopt. In Fig. 41 are shown two methods of gating that can be used with a large variety of molds. With a gate like that marked *d*, the metal will flow in as shown by the arrow *h*. The use of such a gate will cause great friction between the metal and the bottom of the mold, and unless the whole surface fronting the inlet gate is nailed very closely, with the heads of the nails even with the bottom face of the mold, the casting will be scabbed at that point. Instead of nails, strong cores may be used to form all the surface fronting the inlet gate, thus preventing scabbing at that portion of the mold.

51. The best kind of gate to use for such work is shown at *b*, on the right of the illustration. Here the metal, on entering the mold, will come up from the bottom, as shown at *l*, and flow gently over all the face of the mold, with little or no friction that might cause scabs. This form of gate is easier on the face of a mold than any other. It can be applied to a large class of molds. The only objection to its use is that the dirt created in the pouring runner and gates or that may come from the scum of the ladle is not distributed. As a rule, all such dirt will collect in a body and float right above the inlet *l*. In molds having cores or projections by whose use dirt will be caught and confined in the parts especially requiring solid metal, this class of gate *b* would be undesirable. With an inlet gate, as shown at *d*, the dirt is divided into fine particles and distributed to all portions of the casting, which, in some cases, may be preferable, even though a scab is created in front of the gate.

GATES FOR MOLDS

52. Pouring Gates for Catching Dirt.—When the gate *b*, shown in Fig. 41, is used, dirt is very apt to be collected and held in one spot; but there are methods in use that serve to lessen considerably the amount of scum or dirt passing into these gates. Fig. 44 shows some of these methods, which may be modified as deemed desirable. In pouring a casting with a system of dirt catchers, commonly called *skimming gates*, shown in Fig. 44 (*a*), the metal first flows into the depression



(*a*)

Fig. 44

at *d*, filling it so that the core *h* holds back much of the dirt or scum coming from the ladle. Comparatively clean metal should pass from *d* down *e* through *g* to *f*. In the plan (*b*) the connection *g* between *e* and *f* is led to one side of the latter, so that the metal is given a whirling motion on entering *f*, which causes the scum and dirt to rise up into *f*, and comparatively clean metal to pass through *e'* into the mold; *e'* here corresponds to the inlet gates *b* and *d*, Fig. 41. To make this form effective, the inlet gate *e'*, Fig. 44, which leads the metal into

the mold, must have a smaller area than either of the other openings. The flow through e' will be thus *dammed* back, keeping the riser f full of iron, thereby causing the dirt to float on top of it; whereas, did the metal in it descend to the level of e', this dirt would pass into the mold. The drawing in Fig. 44 is not to scale, and the gates, pouring basins, risers, etc. are magnified in order to illustrate their relation to the mold.

53. The sizes of the various gates are shown so as to give an idea of proportions that work well. The parts of Fig. 44 that are lettered, but have not yet been referred to, are m, the pouring basin; i, a core; r, the runner box; and F, the feeding head. With such a system of skimming gates, the under inlet gate b, Fig. 41, can be used with very little risk of having much scum or dirt pass into the mold. If the mòlder desires

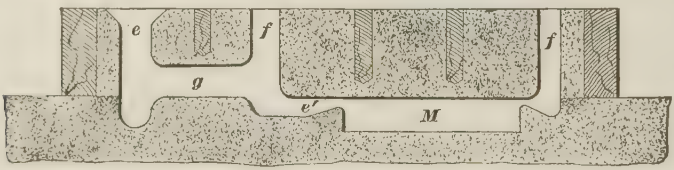


Fig. 45

to decrease his labor in making such a system, the core h and depression d can be omitted and a level bottom used, as indicated by the dotted line j.

A study of Fig. 44 will show that intricate work is evolved in this system; and that unless the molder exercises care and skill, there will probably be more dirt developed by the sand washed from the corners and surface of the gates than would have flowed into the casting had there been but one straight gate and no skimming gates at all.

54. Skimming Gates for Medium and Light Castings.—The arrangement of skimming gates is based on the principle that all scum or dirt is lighter than iron, for which reason it will float to the highest point that it can reach. In arranging skimming gates, some part is so constructed that the dirt, as it rises to the surface of the flowing metal, is caught and held before it can enter the mold. The skimming gates

just described are for heavy castings. Fig. 45 illustrates a method suitable for medium and light castings. The sand is rammed around two sprue pins to form a pouring gate *e* and dirt riser *f*; a dirt-collecting channel *g* is then cut between them. The higher and longer the channel *g* can be made, the better dirt collector it will be. The metal having passed *g* flows on

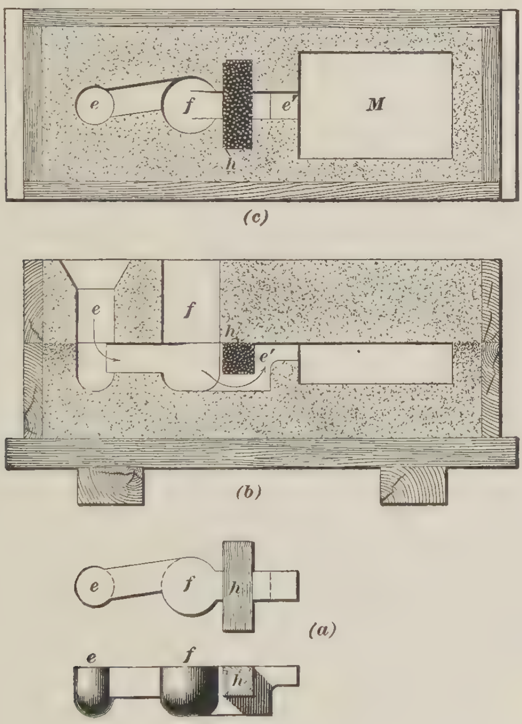


Fig. 46

through *e′* to the mold *M*. In flowing from the gate *g* to the mold *M*, the scum or dirt in the metal, as it rises, is caught and held in the upper part of the channel *g* and dirt riser *f*. Sometimes the channel *g* is cut on a straight line to *f*, and sometimes on a curve, as at *g* and *f*, Fig. 44. If this is done properly, lumps of dirt should be seen whirling on the top of the metal in the dirt riser *f*, Figs. 44 and 45, and when breaking the

channel g after the metal has cooled, dirt should be found in its upper part.

55. The arrangement of skimming gates for light work so as to save all possible labor, is often desirable. This aim may be accomplished by using the appliance shown in Fig. 46 (a), which is a small pattern so arranged that it can be rammed with the pattern in the drag of small boxes or snap flasks. Two patterns or sprue pins are used to form the sprue e and riser f. When the mold is finished, the skimming gate should appear as shown in views (b) and (c), a small core being used as shown at h. The metal on being poured into the gate e flows into f with a whirling motion and in going to the mold passes under the core placed at h, whence it passes through the gate at the entrance e' into the mold, as shown by the arrow. The advantage of this skimming gate is that it can be formed very easily by means of the core h, which is set into the mold after the skimming-gate pattern is drawn. By the use of this core, which is arranged to settle deeply into the gate, the iron that enters the mold is taken from the lowest point of the skimming gate, which insures clean metal going into the mold. It is a simple device, but very effective in its results.

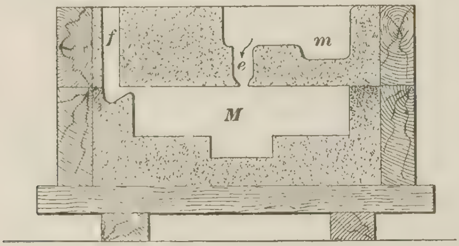


Fig. 47

56. Top-Pouring Skimming Gates.—Another form of skimming gate is that used in top pouring, shown in Fig. 47. This gate is applicable to a great variety of work in both light and heavy castings. In constructing such gates, a pouring basin m is made; the metal enters the mold M through a gate or gates e. By a quick dash of the metal from the ladle at the start when pouring and by then keeping the pouring basin full until the flow-off risers show that the mold has been filled, the dirt will stay on top of the metal in the pouring basin, leaving

clean iron to pass into the mold. It is only when beginning to pour that dirt should have any chance to enter the mold; and this fact is true to a greater or less extent of all forms of skimming gates. There are many forms of skimming gates, but those shown in Figs. 44 to 47 should be sufficient to indicate the principles involved.

Probably the easiest way to obtain clean castings is to keep the pouring basin full during the time of pouring. In these illustrations the gates are shown large in proportion to the balance of the mold to illustrate their arrangement more clearly.

57. Dirt in Castings.—After scum or dirt has entered a mold its natural tendency is to rise to the top, since it is lighter than iron; but under some conditions this tendency cannot be followed. When iron enters a mold, it rapidly loses its fluidity, and for that reason if dirt drifts to the side of the mold, it is liable, on account of the dulness of the metal, to stick there and let the metal flow over it. Again, molds often have projecting cores beneath which, when the metal rises to the under side, the dirt is caught and retained.

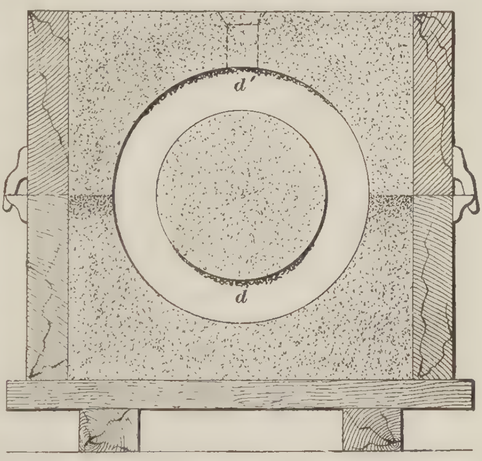


Fig. 48

58. If cylinders or pipes cast horizontally are considered, it will be found that the scum or dirt will lodge as seen at *d*, Fig. 48, and what passes this point will rise to the top and stay at *d′*. On this account it is often necessary, if the inside is to be bored out, to leave extra stock for finishing at *d*. If the castings are columns for supporting buildings, or similar pieces, it would be wise to make them thickest on the top or cope

side at d', to allow for the weakness that the dirt might cause at that point. Even with the same amount of dirt at d and d', and with the drag and cope parts of the casting of the same thickness, the cope will be the weaker side of the casting, as there is less pressure at that point of the mold to make the metal solid.

59. Pouring Basins.—In making a mold, there are few things that require greater care and skill than the pouring basin, which is the basin formed in the top of the cope for receiving the metal from the ladle. Here the greatest amount of friction, rush, and washing-out effect of the metal is produced; and if the basin is not well made, it will be easily cut by the falling metal. If the cutting of the basin once starts, considerable damage may result before the mold is filled. A molder may slight the rest of his mold and yet have his castings come out so that they will pass inspection; but any carelessness or ignorance in making basins, runners, or gates will cause trouble. In pouring a mold, the iron first drops from the ladle into the basin, from which it runs with more or less velocity into the upright sprues or runners, and from them into the gates that lead into the mold. With the exception of that portion of the mold into which the iron enters or drops, there is very little agitation of the metal as it gradually rises in a mold, compared to the rush and spattering that exists in the pouring basin. When making these basins, extra care should be taken to see that the sand has been well mixed and riddled before it is shoveled into the basin box. The use of poorly tempered sand for making basins has often caused bad castings. Some molders shovel a little sand into the box to form the bottom of the basin and then tramp it with their feet or pack it with a rammer, after which they press sand against the sides of the box with their hands to give shape to the pouring basin; this procedure is very bad practice. To make a reliable basin, the box should first be evenly rammed full of sand, after which the shape of the basin can be dug out with a shovel or trowel. The ramming will give a firm, solid body to the sand.

60. The point of danger in pouring basins is at the bottom n, Fig. 44 (a). Here the force of the dropping metal has

such a cutting effect that in large basins, it is advisable to place a core at i; in some cases bricks may be used instead; or again, green sand may be made to take the place of the core or bricks, by closely nailing the bottom where the iron will drop from the ladle, the heads of the nails being left even with the surface of the sand. It will be noticed that a well is formed around the core i, so that immediately after starting to pour, a body of metal will be formed into which the iron drops, and thus save the bottom of the basin n from receiving the full force of the dropping metal. In some cases the well at n can be made so deep that there will be no necessity for cores or bricks. However, it is well to secure this part of a basin as much as possible, for a sudden jerk of the ladle at the start, which often occurs, might prove very serious and result in the loss of the casting. There should never be less than 4 inches of good tempered sand between the bottom of the basin at n and the floor, or other bottom. In the case of very large basins, it is wise to have a cinder bed under them, as shown at C, Fig. 44.

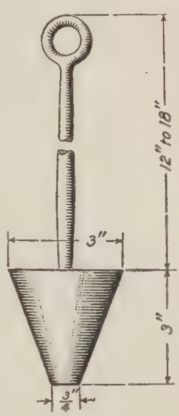


FIG. 49

61. If wooden basin boxes are used, it is well to have their fronts nailed, as illustrated at o, Fig. 44 (b), as the wash of the metal striking the front of the basin has been known to cut away the sand and cause a bad casting. Another point to be carefully watched in making pouring basins is to avoid having water carelessly swabbed around the edges of the gates or the bottom portion of the basin, as the metal may thus be started blowing, and when once commenced, it is hard to tell when blowing will stop. Any boiling of the metal in the basin will bring out more or less scum or dirt that must follow the metal through the gates into the casting.

62. Large castings sometimes require the use of several sprues, to avoid the formation of spongy spots. To obtain the best results when pouring such a casting, the opening of the sprue into the pouring basin should be stopped with plugs like

the one shown in Fig. 49. If the sprues were not closed by these plugs the metal might run into the mold so fast that dirt which should remain in the pouring basin might be carried into the mold. When these plugs are used, the pouring basin can be filled and the plugs drawn one at a time, thus allowing the flow of metal to the mold to start more gradually and reduce the danger of washing dirt into the casting.

GREEN-SAND MOLDING
(PART 3)

IRON MOLDING—(Continued)

PREVENTION OF DEFECTS

DRAWING DOWN OF COPE

1. Cause and Effect of Drawing Down.—Drawing down of the cope is a term applied to copes whose surface sand drops down on the metal as the mold fills up. This dropping is caused by the heat of the metal drying the surface of the cope. If the sand in the cope is not of such a nature as to bake solidly to the depth penetrated by the heat and it does not hang well when one part is drier than another, then the sand will drop on the metal in small quantities and cause lumps and dirt holes in the upper surface of the casting. The tendency to drop depends not only on the nature of the sand, but also on whether the mold is kept air-tight or not. With strong sand in the cope, some molds may be cast with their feeders, risers, etc. all open and no injury will occur to the casting. If this were done with other grades of sand, the whole surface would be drawn down. It is chiefly with such castings as thick plates or heavy blocks, where the cope surface is exposed to the direct heat of the metal from the moment it enters the mold until it comes against the upper surface, that difficulty is experienced by drawing down.

2. Prevention.—Any part of the cope's surface that is exposed for $\frac{1}{2}$ minute to the direct heat of rising metal should have

a strong grade of surface sand for the first $1\frac{1}{2}$ inches. In addition it should be closely gaggered, with the sand not more than $\frac{3}{8}$ inch thick under the gaggers. The first course of sand in such copes should be evenly and firmly rammed; and the weaker the sand, the harder should be the ramming. Weak sand may be strengthened either by mixing flour with it or by wetting it with clay wash or molasses water. After the surface of the mold is finished it should be sprinkled with molasses water; in fact, it is well to do this even with strong grades of sand, where they are expected to be exposed to the direct heat of the metal for more than $\frac{1}{2}$ minute. Use 1 part of flour to from 15 to 25 parts of sand, according to the strength of the latter; the weaker the sand, the more flour is necessary. In some cases where the copes are to be exposed to intense heat, as in very thick plates or anvil blocks, it is often advisable to nail all the surface between the gaggers, keeping the nail heads either even with the face of the cope and covered with blacking, or else $\frac{1}{4}$ inch away from the surface and covered with sand and blacking. In venting green-sand copes that are liable to be drawn down, the vents should not be carried any closer than within 1 to $1\frac{1}{2}$ inches of the surface. For if they are carried close to the surface, they will permit the escape of gases and relieve the pressure against the face of the cope.

Drawing down occurs not only in green-sand copes, but also in dry-sand and loam copes or covers. Both weak and strong sands are used in these latter molds, as well as in green-sand molds. Where there are heavy bodies of molten metal directly under the copes, dry-sand and loam mixtures should also be strong, or else drawing down will occur, as in green-sand work.

PRESSURE OF GASES IN MOLDS

3. Object of Maintaining Gas Pressure in Molds. There is a great deal of difference in the practice of molders in leaving the feeders and risers open or closed while casting. In most cases it is best to pour large molds with all the risers and feeders closed perfectly air-tight. Molds that are likely to have the copes drawn down, or in which the rushing of hot

gases upwards through the risers will have an inclination to draw the gases from the vents in the bottom, should be cast air-tight as far as possible. The rush of hot air and gases through open risers has a tendency to divert the gases generated in the bottom of the mold from going downwards, causing them to pass up through the under surface of molds and producing scabs on the bottom of the casting. This rush also relieves the mold of the internal air pressure that exists when the mold is kept air-tight; and this pressure is often sufficient to prevent weak grades of sand from being drawn down from the surface of the cope.

4. Air, like all other gases, expands with an increase of temperature. At a temperature of 500° F., air has about double the volume that it has when at 0° F. The temperature of the air and gases in a mold is perhaps about one-half that of the rising metal; it may safely be taken as at least one-third. The air and gases in a mold would therefore have a temperature of from 600° to 1,000° F., and the gases in a mold having open risers would be increased in volume to two or three times that before the liquid metal commenced filling the mold. In an air-tight mold the pressure of the air would thus be increased with its temperature. In other words, the air in a mold before casting was begun, would have the pressure of the atmosphere, which is about $14\frac{3}{4}$ pounds per square inch; but by increasing the temperature, the pressure of the air and gases in an air-tight mold would increase from 2 to 4 pounds per square inch over the atmospheric pressure. Such a pressure at the face of the mold is very effective in preventing the surface of the cope from drawing down, and also prevents the gases from rising in the lower part of the mold where they might cause scabs, or worse still, start the mold blowing. In casting small molds the risers can sometimes be kept open without injury, as well as in dry-sand and loam molds that have solid faces with little cope surface exposed to the metal. Aside from these, all risers and feeders should, as a rule, especially in heavy green-sand work, be closed air-tight and weighted down so that any increase of gaseous pressure cannot lift them.

Where risers are left open in any mold, they should be sufficiently large in area to allow the expanded air and gases to escape freely, as air rushing through these passages is likely to do damage by cutting away the sand around them.

5. Covering Feed-Heads and Risers.—When covering the feeders and risers, as at *n* and *o*, Fig. 1, care should be taken, as the smallest opening leaves room for the air and gases to rush out. Their escape would cut the sand and increase the area of the opening as long as the mold was being poured. In placing covers on the feed-heads, as at *n*, the covering plate *p* should have a good bearing over the top of the feeder box or

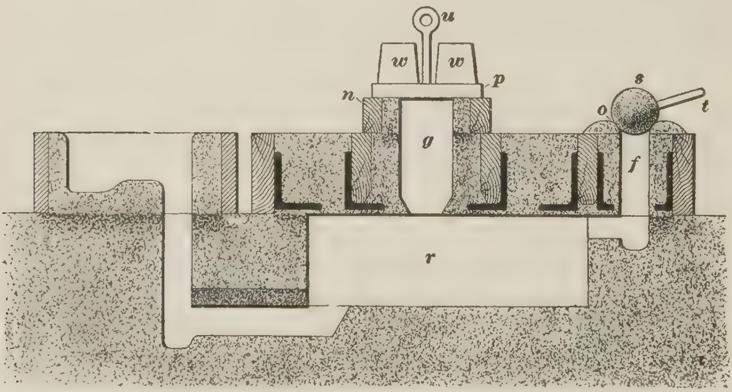


FIG. 1

projection, and to insure a tight joint, flour paste, parting sand, or dry flour is put around the opening for the covers to bear on. Flour paste is the best, and should be used for all heavy castings or work having cope covers or projections where the liberation of compressed air or gases might cause the molds to scab or blow. After the feed-head *g* is covered it should be weighted as shown at *w*. The combined weight of the cover and weights placed on feeders or risers should be estimated according to the possible temperature of the air and gas inside. This point must be left largely to the judgment and experience of the molder. It is always best to have more weight on *p* than is really necessary, for an excess of weight can do no harm. Where feeders

or risers are not more than $2\frac{1}{2}$ inches in diameter, balls of clay are often used, as shown at *s*. These balls of clay should be of such consistency as to hang together well. In some cases it is well to stick a rod in the ball of clay, as shown at *t*, and to have handles on the cover-plates, as shown at *u*.

6. Although there are certain advantages to be gained by closing risers while pouring a mold as just described, there are also advantages to be gained by leaving them open, and molders seem to be about equally divided in their opinions as to which is the better plan. When the risers are left open and the air and gases in the mold are allowed to escape freely, the iron enters the mold more freely. When the casting is to be made of a metal that requires rapid pouring, it is, of course, necessary to have the risers open so that the metal will enter the mold as freely as possible. If the iron has to force the air out of the mold against a considerable resistance, air holes are sometimes formed in the surface of the casting and these holes are not uncommonly charged to the supposed presence of sulphur or phosphorus in the iron. A cope should always be made secure enough to cast with either open or closed risers.

7. Causes of Blowholes.—In pouring a casting with very dull iron, it is sometimes advisable to leave some risers open. Where there is no great danger of the cope drawing down or the gases working upwards from the bottom of the mold, this method is desirable. Too close confinement of the air and gases may cause blowholes in the thinner parts of the casting. Castings frequently have what are called *shrink holes* and *blowholes*. The latter are generally holes having smooth surfaces and are rarely larger than would hold a teaspoonful of water. Castings may be so full of blowholes as to look like a honeycomb.

8. Blowholes, whether in large clusters or singly in a casting, are caused by the gas or steam, generated from the moisture in the sand, facings, etc., that compose the mold, endeavoring to escape. The gas or steam is caught because the metal is dull and solidifies before the gas can pass out entirely. Blowholes may be expected in any casting where the cores do not

vent freely, or where the mold, for any reason, may cause the metal to kick or blow. Where the metal kicks or blows in a mold, the formation of blowholes may often be prevented by flowing metal through the risers. This method is especially effective where the inlet gates carry the metal to the bottom of the mold and flow-off gates or risers are placed at the top. Where hot metal fills a mold that blows or kicks and is slow in solidifying, the gases may free themselves without the flowing of much metal through the risers.

9. Blowholes are of two kinds: *interior*, as shown at x, Fig. 2, and *exterior*, as shown at w and y. The exterior holes are more often found in the form of indentations, as shown at w. Such a formation on the bottom of a mold or casting may be caused by the tendency of gases to collect where the metal is hottest and most fluid. Gases are also liable to collect where there are several vents or where there is a softness in the mold. Where there is a hard spot in the face of the mold, the gases, not finding relief outwards, try to pass through the metal and are caught and imprisoned by the solidifying iron.

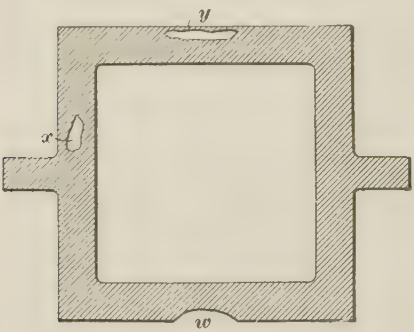


FIG. 2

10. The form of blowhole seen at y, Fig. 2, is generally caused by gases passing from the bottom of molds or cores upwards through the metal in an effort to escape through the cope surface. A damp or hard spot in the surface of the cope will chill the metal and form a thin crust through which the gases cannot escape, and being unable to go any farther, they will be imprisoned and form a hole, as shown. Such holes as at y are chiefly found in castings ranging from $\frac{1}{2}$ to 1 inch in thickness; in such cases the cope exerts a greater chilling effect than it does where there is a thick body of metal. Often the surface of a light casting appears solid until a scraper is passed over it,

when, from the sound made, hollows may be detected. On breaking the crust, it will be found that these hollows or indentations are generally of a very smooth character, which shows that they were formed by imprisoned gases. A remedy for this condition is to have vents in the bottom of the molds so as to allow the gases to pass off freely in that direction, and also to guard against copes having wet or hard surfaces. The drier the sand can be used and the softer it is rammed at the surface of copes covering thin castings, the better.

SHRINKAGE AND CONTRACTION

11. Causes of Shrink Holes.—A shrink hole differs in appearance from a blowhole in that the former usually has a rough surface while the latter has a smooth one. The shrink hole generally looks as if a body of metal, of the same form as the hole, had been torn out, leaving a very rough, open-grained fracture. It is caused by the shrinking of the parts that are the first to solidify and draw metal from those that solidify last. This fact is due to the peculiarities in the cast iron that cause expansion at the moment of solidification, just before contraction takes place. It is also caused by the fact that thin or exterior portions solidify with a closer grain and possess more combined carbon than interior or heavy parts, even when poured from the same ladle of iron. The harder the iron, the more noticeable will be these conditions. With very soft grades of iron little difficulty will be experienced from shrink holes, unless the castings are heavy. Where the iron is hard, either high in combined carbon or low in graphitic carbon, the shrinkage will always be great compared with that of soft iron. For this reason hard-iron castings must be very carefully proportioned, or considerable shrinkage may be expected in the parts that are the last to solidify. These parts should be

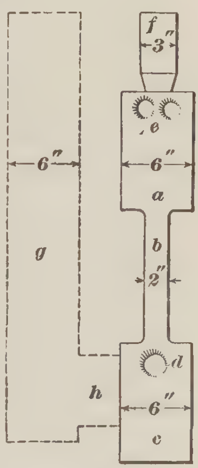


FIG. 3

provided with feeders through which compensation for the shrinkage is made with good hot metal. This point is well shown in Figs. 3 to 6.

12. Molders are sometimes held responsible for shrink holes which it was impossible for them to avoid. For example, consider Fig. 3, which shows a section of a casting having a light body at *b* connecting two heavy ones, as at *a* and *c*. It is evident that the lighter body *b* will solidify before the heavier ones *a* and *c*. Hence such a piece, if cast in a vertical position, will probably have shrink holes at *d*, since after the light section *b* has solidified, the outer portion of *c* will draw metal from the portion that was the last to solidify, forming cavities, as shown at *d*. The holes *e* occur near the upper surface of the casting because iron shrinks when it solidifies and there is therefore not enough metal to fill the mold. When a mold has been poured full of liquid metal, a shell begins to form wherever the metal is in contact with the mold. As the cooling continues, the shell becomes thicker and stronger, so that the shrinkage cannot draw the shell away from the mold and there is not enough liquid metal to fill the inside of the shell. As the thickness of the shell increases, the shrinkage also increases and the surface of the liquid metal in the center continues to settle, thus enlarging the holes *e* near the top of the casting as the casting cools. The holes at *e* in the upper end of such a casting can be prevented by having a feeder *f* through which, after the casting is poured, additional metal may be fed to replace that taken away from the portion at *e*. The only way to prevent holes at *d* in such a vertical casting is to have a feeder leading down to *c*, as indicated by the dotted part *g*, when practicable; but this arrangement is seldom possible in ordinary work. It should also be borne in mind that if the feeder *g* is to be effective in preventing holes *d*, this feeder must be larger than the section *c*, so that the feeder and its inlet *h* will be the last to solidify.

13. Another example of a shrink hole may be seen at the upper end of the vertical casting shown in Fig. 4. Here the riser head *f*, used chiefly to receive the dirt, has an area at *a*

larger than at any other portion of the section. A study of Fig. 3 should make it clear why shrink holes are formed at *a*, Fig. 4. To prevent the formation of such holes, perfect feeding is required. If the feeding is omitted, then the section at *f* should be enlarged to a thickness equal to that of the casting

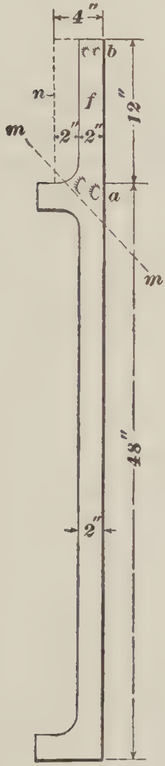


FIG. 4

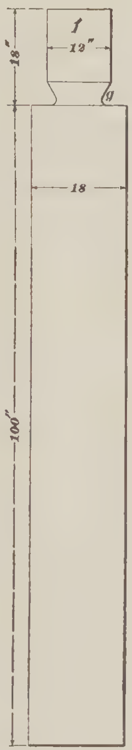


FIG. 5

FIG. 6

measured on the line *m m*. This thickness would give a *sinking head*, like that shown by the dotted line *n*, 4 inches thick instead of the original 2 inches. By having a sinking head 4 inches thick, it will be self-feeding, so that instead of the holes being at *a*, they will be higher up, at *b*. The principle involved in this scheme of self-feeding is also illustrated in Figs. 5 and 6. Here is shown a roll supposed to be cast on end. Some molders,

to save lathe work or labor in cutting off feed-heads from such castings, will place feeders as at *f*, coming down to a neck, as at *g*, and then feed the casting with churning rods and an occasional pouring of hot iron into the feed-head.

14. Instead of depending on care, judgment, and skill in feeding such castings, some molders avoid the neck at *g*, and simply carry the casting up straight, and have it appear as shown in Fig. 6. After these molds are cast, the upper end is covered with blacking to prevent heat escaping, and then the extra length of the casting used for a sinking head is kept full of metal, by occasional pouring as it shrinks away. After the casting is cold, the extra length provided for a sinking head is cut off. The length of the sinking head from *a* to *b*, in some cases, ranges from 2 to 3 feet, in order to insure the body of the casting below the level of *b* being perfectly solid. A great many founders cast hydraulic cylinders, rolls, shafts, cannon, etc., on this plan, having learned from experience that it is the best way to obtain castings free from shrinkage defects.

When thick and thin parts of a casting adjoin, causing shrink holes in the thick part, and a feed-head cannot be used, the holes may be prevented from appearing in the thick part of the casting by chilling that part In deciding whether or not to use a chill, it must be remembered that gray iron is usually hardened by chilling and that a chill can only be used when such a hard spot will not be objectionable.

15. Difference Between Shrinkage and Contraction. The effects of shrinkage and contraction are distinct in their nature and are separated by an expansion that takes place at the moment of solidification. Shrinkage, as here considered, is the decrease in volume of the metal while cooling, until the moment it becomes solid. At that moment there is a slight expansion; but as it is much less than the previous shrinkage, it is rarely noticeable, especially in large castings. After iron has solidified, it again decreases in dimensions until it reaches the temperature of the atmosphere; this process is contraction. While this distinction is not always recognized, yet some such distinction is necessary and these terms will be used as defined.

Light-work molders and founders, not having to make heavy castings, in which the greatest shrinkage is displayed, are very likely to confound shrinkage with contraction. Nevertheless, there are two separate effects and they should be recognized by distinctive terms.

FEEDING THE MOLD

16. Importance of Proper Feeding.—Feeding can be properly done in many cases without the use of large feed-heads, which are objectionable because it is expensive to remove them from the casting. Many molders think that as long as a casting has a feeder, no matter how small, that is all that is necessary. The molder that thoroughly understands the principle of feeding will proceed with discretion in placing such feeders as shown in Figs. 5 and 6. If he has a feeder like that in Fig. 5, he knows that great care and skill must be used to get a sound casting. On the other hand, it is no uncommon thing to see a molder using a feed-head that will solidify almost as soon as the mold is poured, although the casting underneath the feeder may remain in a fluid state for some time. Such castings would be better without any feeder, as a small feeder may draw out more iron than it puts in. Whenever a feeder is used, it should be sufficiently large to permit of feeding the body of metal below it as long as the latter remains in a fluid state. Some molders accomplish this object by means of a smaller feeder than others, although the difference in size may not be great.

Usually, the greatest difficulty in feeding is to keep the smaller sizes of feed-heads open. A head from 2 to 3 inches in diameter should be kept open for from 10 to 15 minutes and the molder should be careful not to employ too large a feeding rod. Sometimes a molder will use a $\frac{3}{4}$-inch round cold-iron rod in a 2-inch feeder. The result is that the cold rod chills the liquid metal the moment it is inserted, and being too large for the feeder, the chilling rarely permits the removal of the rod.

17. Use of Feeding Rods.—For a 2-inch feeder the diameter of the feeding rods should not be more than $\frac{3}{8}$ inch.

For a 3- to 4-inch feed-head, a $\frac{1}{2}$-inch rod will work well. For 4- to 6-inch feeders, $\frac{5}{8}$- to $\frac{3}{4}$-inch rods will work nicely. In all feed-heads above 6 inches in diameter, rods from $\frac{3}{4}$ to 1 inch in diameter can be used. Before being inserted into a feeder, the rod should always be well heated in a ladle of hot metal, so as to prevent it from chilling the metal in the feed-head, which is generally dull, having flowed upwards from the bottom to fill the feeder. When placed in a feed-head, a rod should pass through the head and enter the casting to a depth that will insure hot iron being fed into the part that is going to shrink.

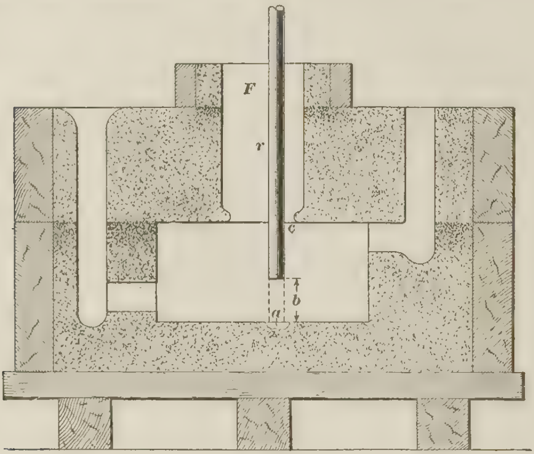


Fig. 7

Too many molders push the feeding rod no deeper than the bottom of the feed-head. Some do this through ignorance and others to get rid of a hot job quickly. In the ordinary molds, the feeding rod *r*, Fig. 7, should be carefully passed down until it strikes the bottom of the mold and then drawn up a few inches, as shown at *b*, to avoid making a lump on the casting at *a*. After the feeding rod has been raised off the bottom, it should be worked up and down, or churned, through a distance of from 3 to 5 inches, according to the character of the mold, keeping it near the outer sides of the feed-head *F*, as shown at *c*. When churning, care must be taken not to strike the sand of the mold.

18. In feeding heavy castings, several feeding rods should be on hand, a few of them smaller than the ones generally used, so that if one rod becomes badly clogged, it can be removed and a clean one used. Clogging of feeding rods may often be prevented by tapping them lightly with another rod held in the hand, as shown in Fig. 8. This tapping jars off the metal that clogs the rod and assists in keeping the feed-head open until the casting has solidified. The partly solidified iron that is jarred off the feeding rod can be worked into the casting,

Fig. 8

thus taking it out of the way of the feeding while still benefiting the casting by helping to cool the metal.

19. Hot Iron for Feeding.—In using feeding rods, care should be taken to have plenty of hot metal, in order to keep the feeder open, so that the metal in the feed-head may be as fluid as that in the casting below the head. This important point is far too often disregarded and molders frequently have difficulty from the start for want of hot iron to keep the feed-heads open. When the necessary hot metal is at hand, feeding

should be continued until the gradual solidification of the casting from the bottom upwards has pressed the feeding rod up to the lower edge of the feed-head. This stage reached, hot metal should be poured into the feeder while the feeding rod is being gradually removed. Any molder feeding in this manner will obtain a solid casting.

Fig. 8 shows a molder in the act of feeding a mold and a second person pouring hot metal from a hand ladle to keep the feeder open and supply the shrinkage of metal in the casting. With very large feed-heads, it is sometimes a good plan to use a small iron scoop and dip out the dull metal in the head for a depth of about 6 inches. The feed-head is then filled with hot metal as direct from the cupola as possible. This metal can be churned up and down with the feeding rod to open the feed-head and so obtain a good, clean hole to continue the feeding. If in feeding a casting the molder will keep his feeding rod hot and have a covering of powdered charcoal over the feed-head, he will experience little or no difficulty from iron adhering to the feeding rod. To be able to keep a feed-head open until the solidifying metal drives the rod out of the casting is an operation requiring skill on the part of the molder.

20. Use of Large Feeders.—Often with feeders over 8 inches in diameter, a feeding rod need not be inserted for quite a time after the mold has been poured, for the reason that the iron does not commence to shrink until it is approaching the point of solidification. This point is not reached until the metal in contact with the walls of the mold or core has cooled down considerably.

Many molders when feeding large heads like that in Fig. 5 cover the metal in the feed-head with dry blacking or charcoal dust as soon as the mold is poured, to keep the heat from escaping, and then pour in hot metal occasionally, as the feed-head settles. This process may be continued in large feeders of over 12 inches in diameter for from 30 to 60 minutes, or as long as it is safe to do so. This point can be determined by occasionally passing a hot feeding rod into the casting and

observing whether any metal sticks to it when pulled out. When iron commences to stick it is time for the molder to put in the feeding rod for constant and careful operation, or until it is driven upwards and out of the casting by the solidifying metal, as already described.

MOLDERS' SUPPLIES

CHAPLETS

21. Types of Chaplets.—Chaplets are used to support or hold down cores which, owing to their shape, are not self-supporting when placed in the mold. There is a large variety of such chaplets in use; those shown in Fig. 9 are called *single-headed chaplets*, and those in Fig. 10 *double-headed chaplets*.

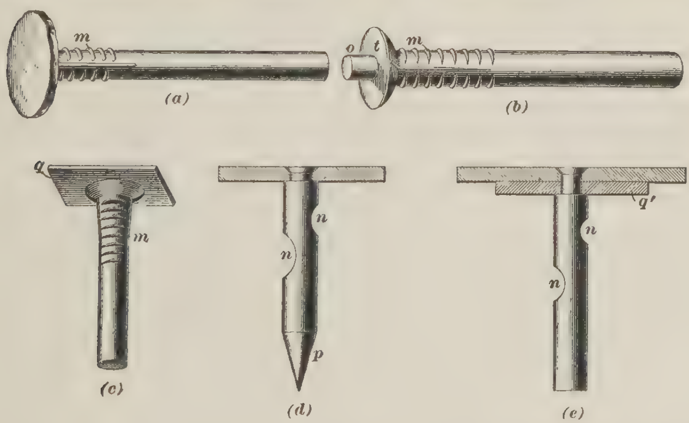


FIG. 9

Fig. 11 (*a*) is a spring chaplet; (*b*) is a combination of chaplet and stand, a scheme often used to save labor and time in setting chaplets; and (*c*) and (*d*) are sheet-metal chaplets. The stand can be set in the drag under the pattern when it is being rammed up and then, when finishing the mold, the chaplet is set in place. Often iron cross-bars in both drag and cope are cast with bosses into which holes are drilled to allow

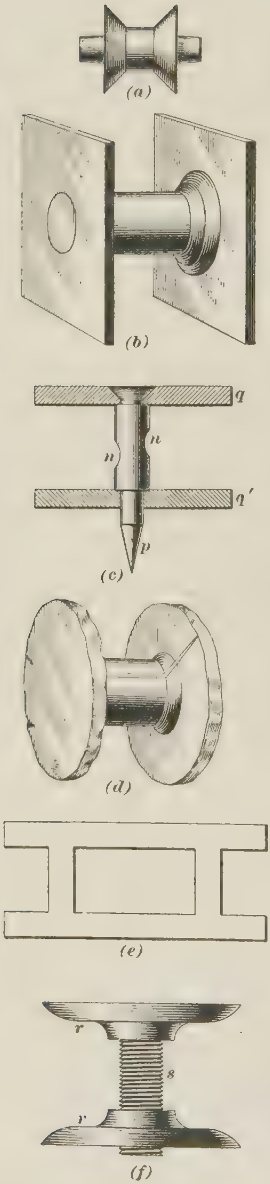


FIG. 10

chaplets to be inserted after the manner shown in Fig. 11 (*b*). The chaplet in (*a*) is made of a piece of steel or iron which can be sprung to the desired form.

22. The chaplet in Fig. 9 (*a*) is made of round iron cut to any desired length and having a solid head; (*b*) shows a chaplet stem, on which, at the head *o*, any size of plate may be riveted. Often larger heads are required than can be forged on a chaplet, as in (*a*), and such chaplets as shown in (*b*) can be fitted with a head of the size desired; (*c*) shows a stem with such a head *q* riveted on. The pressure on a chaplet will sometimes be so great, or the cores will require such a large bearing surface that the plate *q* would be better if reinforced by a back plate, as shown at *q′* in (*e*). The chaplet in (*d*) shows a sharp point *p*, which is sometimes necessary when the chaplet is driven into bottom boards, wooden blocks, etc., underneath the surface of the mold. In driving such chaplets, a depth of $\frac{1}{2}$ to $\frac{3}{4}$ inch is sufficient, as the driving is liable to force down the block or to jar the board and loosen parts of the mold.

23. Fig. 10 (*a*) shows a double-headed chaplet stem, which may be made of any desired length, provided with pins, to which plates of any size may be riveted, as shown in (*b*). To fasten double-headed chaplets to the surface of the mold or core, so that

no jarring of either will move them, the chaplet is made with a sharp stem, as shown at p in (c). These sharp stems are driven into the face of the mold; they seldom need to be more than $\frac{3}{4}$ inch long. The heads q and q' are placed on after the stem has been made, and the top head q is riveted on. A double-headed forged chaplet is shown in (d), while (e) is a cast-iron one. Cast-iron chaplets can often be used; but they must not be placed where they will be struck by the stream of metal from the pouring gates, as they melt more readily than wrought iron. This point must be observed in the use of all chaplets, as many castings have been lost because molders have thoughtlessly set chaplets in front of gates that deliver large bodies of metal; or, again, the quantity of the iron may be small, but so hot as to melt the chaplets.

24. There are several firms that manufacture chaplets, especially those shown in (a), (b), (c), Fig. 9, and (a), (b), and (d), Fig. 10. Chaplets can be purchased so cheaply that any person requiring only a few cannot afford to make them.

Fig. 10 (f) shows an adjustable chaplet, a very convenient appliance where odd lengths are needed. It consists of a stud or stem s, made by threading stock of the required size in the screw machine and cutting it to the most convenient lengths. Ordinary cast-iron washers r are drilled and tapped to suit the threaded stem s. An adjustment of $\frac{1}{2}$ inch, more or less, may be made with the washers r, while a variety of lengths of stems permits the making up of any size. The stem here shown is $\frac{5}{8}$ inch in diameter and the washers $2\frac{1}{2}$ inches.

25. Precautions in Using Chaplets.—Chaplets are apt to weaken the casting at the point where they are placed, in three ways: First, the uniformity of the metal of the casting is broken because the composition of chaplets is seldom the same as that of the castings of which they become a part; second, they work loose and leave holes in the castings, generally caused by blowholes around them; third, they cause porous or unsound metal to form around them. The first of

these evils cannot be avoided; but by good design and care in the making and use of the chaplets, the second and third evils can be greatly decreased and in many cases almost wholly avoided. In regard to the second evil, chaplets should be nicked or have depressions made in them, as at *n*, Fig. 9 (*d*) and (*e*), or else have burrs on them, as shown at *m* in (*a*), (*b*), and (*c*).

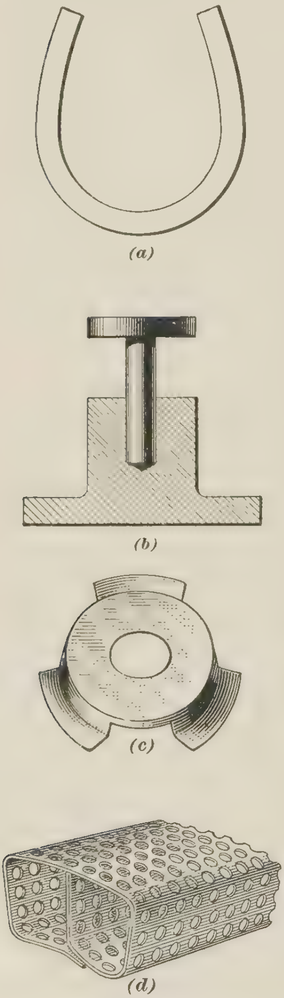


FIG. 11

Some molders, in making the stem, avoid the heavy shoulder *t* shown in (*b*) and make the stem sufficiently large to give a good bearing to the head *q* in (*c*), as shown in (*d*) and (*e*). Sometimes a thread is cut on the part of the stem that is cast in the metal, even in chaplets that have fixed heads. This scheme is used also in making double-headers, as in Fig. 10 (*b*), and in such cases a thread will be cut the whole length of the stem and the heads screwed on, as in (*f*). The screw stem has another very important advantage, as the cutting of the thread removes all scale or rust from the surface of the stem.

The chaplets shown in Fig. 11 (*c*) and (*d*) are suitable for light work. The chaplet shown in (*c*) is made of thin sheet metal and can be used only for light, thin work. The chaplet shown in (*d*) is also made of sheet metal; but it can be bent into a greater variety of sizes and shapes than the one shown in (*c*). The perforated chaplet can be used for thicker and heavier work than the one shown in (*c*); but it cannot safely be used for very heavy work.

26. Rust on Chaplets.—There is always more or less rust or scale adhering to the surface of both old and new chaplets. As much of this rust as possible should be removed from the parts that are cast in the metal. When molten metal comes in contact with rust, a gas is formed. The space that the gas occupies depends on the pressure; and the harm it can do depends on the rapidity with which the metal solidifies and prevents the gas from escaping. Blowholes are rarely found around the chaplets in the lower part of a casting; they occur in the upper part, where there is very little pressure during the pouring. The part of a mold where the greatest pressure exists is usually the first to be filled and the iron is also hotter and cleaner there than at the top of the mold. If, for any reason, the chaplets at the bottom should cause the iron to boil or blow, the gas will generally escape upwards through the metal and out at the top of the cope sand or out of the flow-off gates.

Chaplets may be free from rust when placed in the mold, but if kept there for two or three days before the mold is cast, they are very apt to become rusty, especially if a green-sand mold is used. There are coatings that can be used to prevent the rusting of chaplets, and these will be dealt with further on.

27. Moisture on Chaplets.—A piece of polished iron, if exposed to moist air or otherwise moistened, soon becomes rusty. Under certain conditions, polished iron can be protected from rust by keeping it in a dry atmosphere. Take polished iron from a cold room into a warm, moist one, and rust will soon be formed on it. This formation is caused by the condensation on the surface of the cold iron of whatever moisture there may be in the air immediately surrounding it. The more rust there is on iron, the more moisture will be collected; and on chaplets this moisture can do greater injury than rust. To test this, heat a rusty rod sufficiently to dry all its moisture, after which place it quickly in a ladle of molten iron. The metal will buble around the rod, more or less; but it will not fly out of the ladle as it would if there were moisture on the rod.

The steam from the moisture on chaplets may cause a great amount of bubbling or blowing, as can be seen by quickly immersing a damp rod in a ladle of iron.

The best way to prevent chaplets from becoming rusty and collecting moisture is to tin that portion liable to be incased by the metal. Coating the iron body with tin not only prevents rusting of the iron, but the tin makes the iron more fluid when in a molten state, and thus greatly aids the release of any gases that might be created around the chaplets.

Where chaplets are not tinned, they may be covered with a coating of red lead mixed with turpentine. Asphaltum, coal tar, and chalk are often used as a coating. Where there is much moisture, sufficient dampness may be collected to cause injury, but not to such an extent as with rusty chaplets.

28. Setting and Wedging Chaplets.—Few things are more annoying than the loss of castings by thoughtlessness or ignorance in setting and wedging chaplets. Chaplets are generally set into a cope by first passing a $\frac{1}{8}$-inch rod or vent wire up or down through the cope at the spot where it is desired to place the chaplet. If the chaplet is larger than $\frac{1}{4}$ inch, then a $\frac{1}{4}$-inch vent wire or rod is passed through the hole made by the $\frac{1}{8}$-inch rod, and so on, increasing the size of the rods according to the size of the chaplet stem, the idea being to gradually enlarge the hole for admission of the stem without applying much pressure. After the stem has been pressed through the body of the cope, it should then be pulled out and the hole reamed out at the face of the mold, as shown at *c*, Fig. 12. Many molders having failed to ream the hole so that when pressing the chaplet down to a good bearing on the core, or in wedging it down to place, have caused the face of the mold around the bottom of the stem to be pulled down, as at *d*, resulting in the loss of the casting.

29. After the chaplets have been set and the cope closed, some molders drive in wedges with a hammer to fasten the chaplets, as at *e*, *i*, *j*, etc., Fig. 12. This action results in displacing the chaplet, as shown. The chaplet should be placed solidly upon the core *A* and then wedged down, as shown at *f*.

Then, again, some molders in fastening down cores having slanting surfaces use chaplets having the head at right angles with the stem, as at *g*. Where the surface of the core is slanting, the heads of the chaplets should be set on the stem at the same angle as that of the core; care should be taken that the slant of the head and core agrees, so that they may come solidly together when the cope is closed, as at *h*.

30. Blocking on Top of Chaplets.—Very often some blocking will be required on top of the chaplet stems, as at *5*,

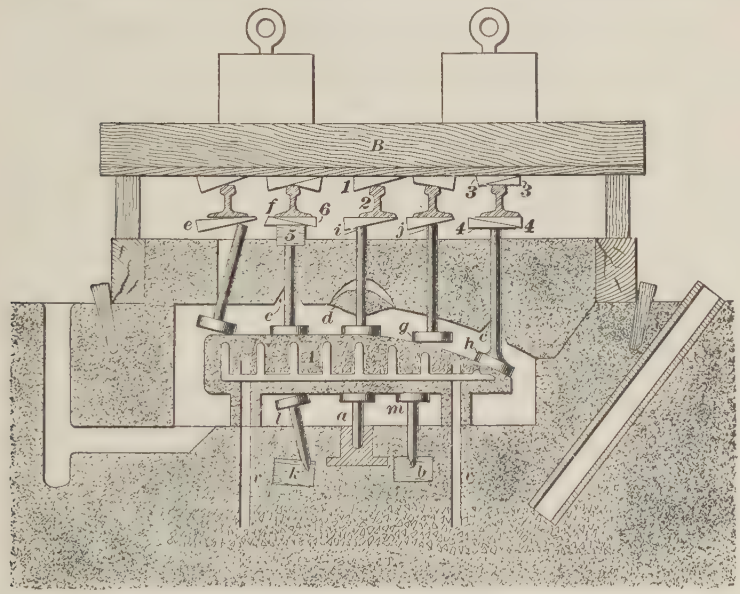


Fig. 12

Fig. 12, before wedges can be used. Where this is necessary, the blocking should be over the center of the stem and sufficient space should be allowed to use the wedges *6*. While it is often necessary to use blocking, there are many cases where its use can be avoided if judgment is used in placing the rails, in weighting down the binder *B*, and in getting the chaplet stems the right length. Molders often leave the chaplet stems sticking up from 3 to 6 inches above the top of the cope;

and sometimes they leave them from 1 to 3 inches below this same level.

Lack of system and judgment causes some molders to use a large amount of blocking to fasten down chaplets, where others will do the same work without any blocking. The fewer pieces of blocking that are placed between the weighting-down binders or rails and the wedges necessary to fasten the chaplets, the better it is for the safety of the mold. In many cases, with forethought and judgment the chaplets can be cut to such a length and the binders can be so arranged as to avoid the necessity of using any blocking between the top of the chaplet stems and the bottom of the weighting-down binders. Where this arrangement is possible it should be made; and the space for wedges between the top of the chaplet stems and the bottom of binders, should range from $\frac{1}{2}$ to $\frac{3}{4}$ inch. Before wedging the chaplets, the weights necessary to hold down the cope should be placed on it, as all the binders, etc. will spring more or less when weighted; and if the weights are placed after the chaplets are wedged, this springing may drive the chaplet heads into the face of the cores and cause damage. Just before pouring a mold having chaplets, it is good practice to go over it to test the wedges, as they sometimes work loose after they have been tightened.

31. Placing Chaplets in Bottom of Mold.—It is as important to have chaplets set correctly in the bottom as in the top part of molds. A large number of the chaplets used in the bottom of molds are driven into the bottom boards or into wooden blocks. Where wooden blocks are used to support cores of any great weight, it is best to make them of hard wood and set them with the grain up. In driving the points, as at b and k, Fig. 12, the molder must use his judgment as to the proper distance, taking into consideration the size of the chaplet stem, the weight of the core, and the nature of the block.

32. Some molders lose castings by the manner in which they set bottom chaplets. The block k, Fig. 12, is apt to split for two reasons: first, because the chaplet has been driven in too far; and second, because the point is near the end of the

block. The proper practice in these respects is shown in block *b*. Where points are driven as at *k*, castings are very likely to be lost through the settling of the chaplet into the block. Even if the weight of the core does not cause the settling, the wedging down of the top chaplets when the cope is closed will probably do so. A fine wire should be pressed through the sand to find the end of each block, so that the chaplets may be driven near the center of each block. The head of chaplet *l* is shown in such a position that it makes an angle with the core and has but one edge touching it. It can readily be seen that a core should be set solidly on the chaplet, as at *m*. A chaplet placed in a stand is shown at *a*, the appliance being illustrated in Fig. 11 (*b*). These stands are very good for some classes of castings, as, for example, in cases where it does not matter if the face of the casting is chilled a little at and around the spot of the chaplet connection. By placing sand in the bottom of the hole admitting the chaplet's stem, provision can be made for any variation in the thickness of the metal.

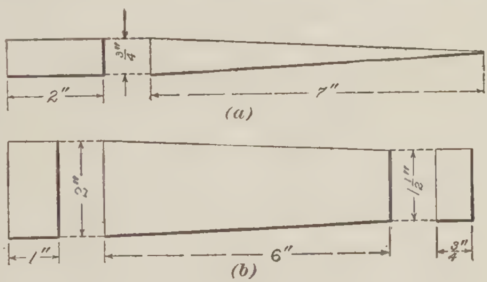


FIG. 13

33. Wedges for Setting Chaplets.—Wedges should be made with as little taper as practicable. The greater the taper, the more difficult it is to fasten the wedges and the more likely they are to work loose. The wedges shown in Fig. 13 represent good practice. They can be fastened without much danger of being loosened when other wedges are being driven. The wedge in (*b*) is generally used to resist great strains and to partly take the place of blocking; it can be made of any size to suit the conditions of the work. The wedge shown in (*a*) is most commonly used and the dimensions given can be applied to either cast-iron or wrought-iron wedges.

MOLDING SAND

34. Adhesive Qualities.—Molding sand is a mixture of sand or silica with a certain amount of clay or binding material that aids the sand in retaining any shape given it by pressure. The term molding sand covers a large variety of sands employed in the different branches of green-sand molding. Sand is said to be *sharp* when its individual grains are angular, and *dull* when its individual grains are rounded. Sand is said to be *strong* when a body of it inclines to retain any shape that may be given to it, and *weak* when it tends to fall apart and will not retain a given shape. Other things being equal, the sharper the sand, the stronger it is; but the sharpest sand is weak without some cementing material, as clay. Sharp sand alone will not hold its shape, while too strong a sand will not permit the gases to escape through it during the casting.

35. Grades.—The sand for making green-sand molds should vary in its physical qualities according as the castings to be made are light or heavy. For light castings the sand should be of a fine grain, and for heavy castings sands should be of an open, coarse-grained texture. If the sands best fitted for heavy work are used in making light work, the castings will have a rough skin, or surface. If the fine sands suitable for light castings are employed for making heavy castings, there will be great danger of creating scabs or causing the castings to blow, as the fine texture of the sand will not allow the gases created at the face of the mold by heavy bodies of molten metal to escape freely through the sand and vent holes. Fine sand also tends to form a vitreous coating or scale on large castings, which can be removed only by pickling in acid.

36. Chemical and Physical Properties.—Sand varies more in its physical properties than in its chemical composition. The chief constituent of sand is silica, though it contains alumina, magnesia, lime, iron, soda, and combined water. Different sands vary in the proportion in which these elements are combined. The character of the sand for molding purposes thus depends, to a large extent, on its composition, as will

be explained later. The variation in physical properties is even greater, but not more important. The sand may be fine or coarse, according to the size of the grains. The class or grade to which a certain sand belongs depends on the fineness of the sand. A detailed method for determining the fineness will be given later.

37. *Silica* is the fire-resisting material; it has no bond, that is, it has no binding property; consequently, in a sand where adhesiveness is required, alumina must be present. Silica alone is very refractory; but by its union with some elements, silicates are formed that fuse or melt about as follows:

Silicate of alumina melts at 4,350° F.
Silicate of magnesia melts at 3,960° F.
Silicate of lime melts at 3,810° F.
Silicate of iron melts at 3,270° F.
Silicate of soda melts at 1,500° F.

When soda or potash is present, silicates are formed at low temperatures. Iron melts at 2,200° to 2,300° F.; and a sand containing much iron, soda, or potash will be fused into the molten metal.

38. *Alumina* causes the particles of sand to hold together; hence, a sand high in alumina is said to be strong, or possess bond. Alumina is very refractory, but, unlike silica, it is baked together like pottery at a high temperature; consequently, too much alumina must not be present in molding sand.

39. *Lime* may exist in sand as oxide, hydrate, carbonate, or sulphate, but usually as carbonate or oxide. The carbonate is the most objectionable. Most of the lime salts are converted into oxides on burning; consequently, excess of lime will cause a mold to either drop or crumble.

40. If *combined iron* is present in molding sand, it may be converted into ferric oxide by heat and, in the presence of silica, produce slag. *Manganese* in sand acts in a similar manner to iron, but is not so energetic. *Magnesia* is very similar to lime, but less harmful, as it is more refractory.

41. *Organic matter* gives bond to sand, but the bond is destroyed by the burning of the organic matter as soon as it comes in contact with the molten metal, causing the sand to shrink and fall or crumble.

42. *Combined water* is water that has entered into chemical combination with other substances. It is always present in high alumina sands. When the sand is heated to a high temperature the combined water is driven off compelling the sand to shrink. This shrinkage may cause the surface of the mold to crack.

43. Determination of Fineness and Quality.—Fineness of sand can be determined by the use of riddles, when a standard has been decided on. A good standard, and one that has been used to grade fineness, is to sift the sand through five riddles of 100, 80, 60, 40, and 20 mesh. Exactly 100 ounces of sand is sifted 1 minute in the 100-mesh riddle; the part that goes through is weighed, and the balance riddled in the 80-mesh riddle and the process repeated on all the other sizes of riddles. Any loss is credited to the 60-mesh riddle, and any sand that does not go through the 20-mesh riddle is credited to a 1-mesh riddle. The weights of sand going through each riddle are then multiplied by the mesh and the total divided by 100, which gives the degree of fineness.

The following example will more clearly illustrate the method and calculations:

Weight of Sand Passing Through Ounces		Number of Mesh of Sieve	
55.22	by	100	5,522.00
20.89	by	80	1,671.20
11.64	by	60	698.40
10.57	by	40	422.80
1.20	by	20	24.00
.06	by	1	.06
.42 loss	by	60	25.20
100.00			8,363.66

Thus, 8,363.66 divided by 100 gives 83.64 per cent. as the percentage of fineness.

By this method the sand is divided into five grades, according to its fineness.

Grade		Degree of Fineness Per Cent.
No. 1.	Superfine	Above 100
No. 2.	Fine	90 to 100
No. 3.	Medium	75 to 90
No. 4.	Coarse or heavy	55 to 75
No. 5.	Extra coarse	30 to 55

44. Every sand is designated not only by a grade number for fineness but also by a class distinction for chemical composition. There are three classes of sand used in the foundry; they are *silica* or *fire-sand*, *molding sand*, and *core sand*. A sand marked No. 3 molding sand is No. 3 grade in fineness and molding sand as classed by chemical composition.

45. Silica, or fire-sand, is used for steel castings and where very high temperatures are necessary. Good fire-sand will usually run about 98 per cent. of silica, with very little alumina, lime, magnesia, and combined water, and not more than a trace of iron. The following is an analysis of a good fire-sand:

	Per Cent.
Silica	98.04
Alumina	1.40
Iron	.06
Lime	.20
Magnesia	.16
Combined water	.14
Total	100.00

Specific gravity, 2.592.

46. Molding sand for cast iron generally contains from 75 to 85 per cent. of silica, 5 to 13 per cent. of alumina, usually less than 2.5 per cent. of lime and magnesia, not over .75 per cent. of soda and potash, generally less than 5 per cent. of iron, and seldom more than 4 per cent. of combined water.

47. The quality or chemical composition of a core sand, according to some authorities, is of minor importance, the

degree of fineness being the main feature. As a rule, a good core sand should be high in silica and low in alumina. The bond for core sand is obtained by adding resin, flour, etc.; consequently, the desired effect is produced with a high silica sand or with sand low in alumina and iron. A sand low in alumina and iron will permit the gases to escape rapidly, whereas a high alumina or a clay sand will be baked and hold back the gases.

48. Localities Where Molding Sand Is Found.—Molding sand suitable for medium-weight and heavy green-sand castings is found in almost every part of the United States. Sand for light work is the most difficult to obtain; for many years light-work foundries were compelled to rely wholly on the fine sand found in and around Albany, New York; but sand suitable for such work is now found in many states. Sand for statuary work in bronze is still imported from France, no suitable substitute having been discovered in America.

FACING MATERIALS

49. Composition of Sand and Facing Material.—In order to obtain a smooth surface on the casting, it is essential that the sand forming the face of the mold should be well tempered and riddled. For most work the sand should be mixed with some protective material to keep the sand from fusing. Molding sands are composed of silica and alumina, with small quantities of lime, oxide of iron, potassium, and magnesia. The three latter elements are easily fused; they combine with the silica to form silicates or a kind of glass that on heavy castings may form a scale varying in thickness from $\frac{1}{100}$ inch up to $\frac{1}{2}$ inch, if the face of the mold is not protected with some non-fusible material—that is, with some substance incapable of being melted. The face of the mold may be protected by mixing finely ground sea coal with the sand, or by facing the mold with blacking. When the melted metal is poured into a mold that is faced with *sea coal*, the coal is partly burned, producing a dense smoke that coats and protects the mold.

In some cases a facing sand containing sea coal is used and this surface is covered with blacking.

50. Sea coal in America is made from bituminous coal. In addition to mixing sea coal with the facing sand, the surfaces of molds are often covered with what is called *blacking* or *lead*. Blackings consist chiefly of carbon, the other ingredients being alumina, silica, lime, and iron. The less of these latter elements present, the more intense heat the blackings will stand before fusing. The cheaper blackings are composed chiefly of coal dust, or culm, with the addition of various minerals. When ground to a powder these blackings lack cohesion, and therefore are apt to float or wash before the iron when the mold is being poured. Various minerals or clays are therefore ground in the blackings to give them cohesion. The finer the coke or carbon is ground, the more cohesion will it possess; and when ground very fine, the cohesion may be sufficient to hold the material together without the use of any bond. Lehigh blackings are made by grinding to a dust a good quality of Lehigh coal. Coke blackings are made from good grades of coke, selected from a grade having the highest fixed carbon, which at times runs as high as 90 per cent. Gas-house coke being practically a pure carbon, makes excellent blacking; but, it is a difficult material to grind and bolt and is not in much favor with the blacking manufacturers. In order that charcoal may make a good blacking, it must be made from some hard wood, such as hard maple, and be carefully burned. Soft or stringy-grained wood is useless for this purpose.

51. *Plumbago* or *graphite* is recognized as being the least fusible material used for blacking. The best grade of imported graphite comes from the island of Ceylon. In its crude state it looks like bright chips of burnished silver, from which fact it is commonly called *silver lead*. This grade of graphite is not only very valuable for mixing with blackings intended for green-sand, dry-sand, and loam work, but it is also good to dust in a dry state over the surface of molds, as it assists in slicking the mold and peeling the casting. Graphite is extensively used in many foundries. In putting it on a mold, many molders use

camel's-hair brushes, while others shake it out of a bag or throw it on by hand. High grades of graphite excel all other blackings in peeling a casting and giving it a fine, smooth face and bright color. Some grades of graphite are procurable in this country. North Carolina produces some graphite, but it is mixed largely with clay and other undesirable substances. Graphite is also found in Eastern Pennsylvania and in Tennessee, but the best grade comes from near Ticonderoga, New York.

Blacking materials are sometimes called leads, owing to the fact that graphite is called *black lead* or *silver lead*. Blacking materials never contain metallic lead.

52. Sea Coal in Facing Sand.—As a rule, the heavier the casting, the more sea coal is required in the facing, the strongest facing being 1 part of sea coal to 6 parts of sand. If more sea coal than this is used on any casting, the surface is likely to be streaked or veined, especially in heavy work. Where the molds are heavily coated with good graphite, or are poured with dull iron, the effect will not be so pronounced. If facing sand contains too much sea coal, it will prevent light castings from running sharply, and is very apt to cause *cold shuts*. This is the condition brought about when two bodies of fluid metal run together but fail to unite. The surface of the casting will be harder than if a weaker facing had been used; this is due to the gas that sea coal generates when the mold is being poured. This gas is liable to form a cushion between the mold and the metal, and the amount of cushioning depends on the speed of pouring, the amount of pressure, and the fluidity of the metal. When the facing sands contain too much sea coal and the castings are poured *dull*, the metal often becomes set before the gas can pass out through the vents. This condition prevents the metal from running into the corners and edges of the mold and may also cause cold shuts. Then again, these gases may make smooth dents in castings, as shown at w, Fig. 2. Another effect sometimes produced by sea coal is the coating of the surface of the castings with what might be termed coal soot. However, to bring about this condition to any great

extent, a combination of circumstances that seldom occurs must exist. While the conditions described are usually to be found in light-weight and medium-weight castings, heavy castings, when poured with dull iron, may also present some of them.

53. The proportion in which sea coal is mixed with sand ranges from 1 in 20 to 1 in 6. Castings under $\frac{3}{4}$ inch in thickness seldom require any facing sand. Below $\frac{3}{4}$ inch thickness, better and smoother castings are often obtained by using common heap sand, well tempered and riddled finely on the patterns, especially when the metal cannot be poured quickly. In general, castings from $\frac{3}{4}$ to 1 inch thick require facing sand having 1 part of sea coal to 12 parts of sand; above 1 inch and up to 2 inches, 1 part sea coal to 10 parts sand; from 2 to 4 inches, 1 part sea coal to 8 parts sand; all above 3 inches in thickness, 1 part sea coal to 6 parts sand. In mixing facing sand, some molders use common heap sand, or old sand mixed with new in varying proportions, according to the strength of the different sands.

54. The thickness of the casting does not always regulate the strength of the facing sand. There are many other things to be considered: (1) whether the casting is to be poured with hot or dull iron; (2) the distance of some parts of the mold from the point where the metal enters; (3) the time required to fill the mold with iron; (4) whether the metal is running over flat surfaces; and (5) is covering them slowly or quickly. Strong facings on the sides of a mold, where the iron runs in and rises slowly, may be the cause when heavy castings are cold shut. The square corners of castings should, generally speaking, have weaker facings on them than the straight, plain surfaces, and the lower parts of high molds should have a stronger facing than the upper portion. If the strong facing suitable for the lower portion were used at the upper portion, the casting at the upper part would be curly or partly cold shut at the surface, owing to the dullness of the metal when it reached the upper portion of the mold. A new sand will require more sea coal than if it were mixed with old or common heap sand.

Where molds are long in preparation, or are to withstand rough usage in drawing the patterns, it is best, if there are no conditions prohibiting it, to use new sand in mixing the facings. For copes covering heavy castings, the use of all new sand is preferable. For light-work copes that cover flat surfaces, it is best, when the new sand is strong, to use some old sand with it, sometimes equal proportions.

55. Mixing Facing Material.—Castings are sometimes found streaked, veined, cold shut, or not peeled, because the sea coal in the facing had not been thoroughly mixed with the sand. When castings are very massive, the greatest possible percentage of sea coal is mixed with the sand, in order to peel the casting. Much more sea coal can be added to some sands by thorough mixing than would otherwise be possible. In some cases facings may be mixed for massive castings with as high a proportion as 1 part of sea coal to 5 parts of sand, provided the mixing is thorough. A good way to mix facing sand thoroughly is to tramp it with the feet and cut it from 2 to 4 times, and then at the last cutting to riddle it through a $\frac{1}{2}$-inch riddle and then through a $\frac{1}{4}$-inch riddle, and finally through a riddle before applying it to the face of the pattern. In cutting the sand, it should be well scattered. The best way to mix sand, however, is with a sand grinder, which is a machine for breaking up lumps and mixing the sand thoroughly.

GREEN-SAND MOLDING

(PART 4)

IRON MOLDING—(Continued)

MOLDING BY BEDDING IN

LEVELING

1. Bedding in is the process of making a mold by setting the pattern in a sand bed so that the joint is even with the surface of the bed. These molds may or may not have copes. The bed in which the mold is to be made must first be leveled by means of the straightedges *a*, *b*, and *c*, Fig. 1. In leveling up the straightedges, the first one *a* has a mound of sand placed under each end, so as to keep its under edge free from the floor, and is made nearly level by eye. A spirit level is then placed on it and the high end driven down with a wooden mallet or a hammer, the pounding being done on a block of wood as in Fig. 2, to prevent marring the face of the straightedge. The straightedge *b* is then placed on two mounds of sand, as was done with *a*, setting it by eye as nearly true with *a* as possible. The straightedge *c* is then placed on the ends of *a* and *b*, Fig. 1, and the spirit level used to make the ends *b* level with *a*. The leveling can be done by first bringing one end of *b* to the level of *a* by using the straightedge *c* as shown and then carrying *c* to the other end and repeating the operation. Still another plan to level *b* with *a* is to use *c* as shown, and then remove the spirt level from *c* to *b*, and raise or

lower the other end of *b* as may be found necessary. When this method of leveling is used, it is advisable to check the results by leveling both ends across from *a* as in the previous plan.

Fig. 1

2. It must be remembered that the edges of the straightedge *c* must be parallel; in the case of *a* and *b*, however, the upper edges only are required to be true. These straightedges should have a hole in one end so that they can be hung up when not

Fig. 2

in use. They should not be left lying around on the floor, where they are liable to have their edges injured or to be bent or warped from uneven supports and exposure to dampness.

The straightedges are usually set with their top edges about even with the foundry floor. In this case, the setting of the straightedges differs from the method already described, in that they are set in trenches and not on top of the floor.

MAKING THE BED

3. General Remarks.—The straightedges having been leveled as described, the work is proceeded with according as the thickness of the casting to be made requires the bed to be hard or soft. In pouring castings in open sand—that is, pouring flat plates without a cope covering—a soft bed is generally used. The bed, when down or under vents are not employed, must be soft to permit the gases to escape freely from the sand, for there is no head pressure of metal on the bed to drive out the gases as there is when a casting is poured through a cope. In the latter case, the bed is generally made hard to withstand the head pressure of the metal. Much more labor is required in making a hard bed than a soft one.

4. Making a Soft Bed.—In making open-sand plate castings, the bed must be softer for a casting from $\frac{1}{2}$ to 1 inch thick than for one whose thickness is from $1\frac{1}{2}$ to 3 inches, as the thicker the casting, the greater is the pressure exerted by the metal on the bed, tending to drive the gases downwards into the lower part of it or to cause them to escape outwards at its sides. Thick plates can sometimes be made in molds that are as soft as those used for thin plates; but it is usually best to make the mold as hard as possible without needlessly restricting the escape of gases. If the bed is too soft, the weight of the iron will compress it, making the plate thicker than was intended and probably of uneven thickness. By using care in smoothing soft beds with the trowel and in laying on the patterns, a casting can be produced with almost perfectly true surfaces.

5. In starting to make a bed after the straightedges have been leveled up, sand is tucked solidly under *a* and *b*, Fig. 1, so as to prevent the pounding action of the straightedge *c* from disturbing their level. After this is done, sand is shoveled

on both the inside and outside of *a* and *b* until it is level with their tops. The sand on the outside is then packed down with a butt rammer or with the feet, to prevent the pressure of sand on the inside of *a* and *b* from moving them outwards. Next, the straightedge *c* is used to strike off the sand level with the

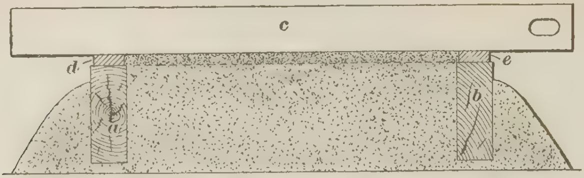


Fig. 3

top of *a* and *b*. Sand that has been passed through a $\frac{1}{4}$-inch riddle is now spread over the face of the bed to a depth of about $\frac{3}{4}$ inch and then a flat piece of wood or iron about 8 inches long is placed on each of the straightedges. These pieces *d* and *e*, Fig. 3, should be from $\frac{1}{4}$ to $\frac{1}{2}$ inch thick, according to the

Fig. 4

desired hardness of the bed; the thicker the piece, the harder will be the bed produced.

6. On top of *d* and *e* is laid the straightedge *c*; a man is then stationed at each end, holding the pieces *d* and *e* and also one end of *c*. These men then pull the straightedge *c* and the pieces *d* and *e* along, sweeping to the end of the bed all sand

that lies above the level of *d* and *e*. A body of sand is left, the thickness of the pieces *d* and *e* projecting above the level of the straightedges *a* and *b*, which sand is next pounded down to the level of *a* and *b* by means of the edge of *c*. A helper holds one end of *c* down on one of the straightedges *a* or *b*, while the molder raises the other end from 4 to 6 inches and brings it down on the raised sand so as to drive it down to the level of the top of *a* or *b* on his side, as shown in Fig. 4. When he has gone a distance of from 12 to 15 inches, he returns about 6 inches and holds his end of *c* down on the under straightedge, *a* or *b* as the case may be, while the helper raises the other end of *c* and pounds down the sand on his side. This operation is continued by the two men alternately, until the whole surface of the raised sand is pounded down to a level.

7. When the bed has been pounded down, its surface will present a series of imprints of the straightedge *c*. To remove these marks and strike off the surface, the straightedge *c* is

FIG. 5

dragged in a seesaw manner across the face of the bed, as shown in Fig. 5, each man being careful to have every stroke a forward one. If this were not done, marks caused by the backward

motion of the straightedge would be left on the surface, while the portion that was done properly would be smooth. The portion of the bed shown in Fig. 5 that is nearest the straightedge has been done properly, while the portion near the front of the illustration has been struck off with alternate forward and backward movements of the straightedge so as to leave ridges of sand on the bed.

8. To accomplish this forward movement requires a little practice, as it is rather difficult to have every movement a forward one while seesawing the face of the bed. If the face of the bed is struck off by a *straight pull*, not only will the surface be left rough, but the operation is apt to loosen the face

Fig. 6

of the pounded sand from the underlying soft body, so that the sand is liable to be loosened or lifted, when the metal runs in, in such a way as to cause a rough and scabby casting. The molder can then build up the sides of the mold with sand and so give any shape required in the casting. A clear idea of this process may be gained from Fig. 6, which shows a molder packing sand against the side of the pattern P in such a manner as to form the sides of the mold.

The sides of the mold having been built up as described, a pouring basin g is made. Pig iron is placed at each side and at the back of the space in which the basin is to be made and sand is then piled over and around the pigs, thus forming the basin inside of the space bounded by them. The pouring basin g

should be made quite deep on the further side from the casting, gradually becoming shallower toward the front where the iron is to flow into the mold. The iron will then flow quietly into the mold and will not tend to wash the sand away. In order to further reduce the danger of cutting the bed, it should be surfaced with fine facing sand in front of the gate, as shown at *h*.

9. Thickness of Open-Sand Castings.—The thickness of an open-sand casting is not necessarily the same as the depth of the mold. If the iron is sluggish and pouring is continued after the mold is full, the iron may be made to pile up

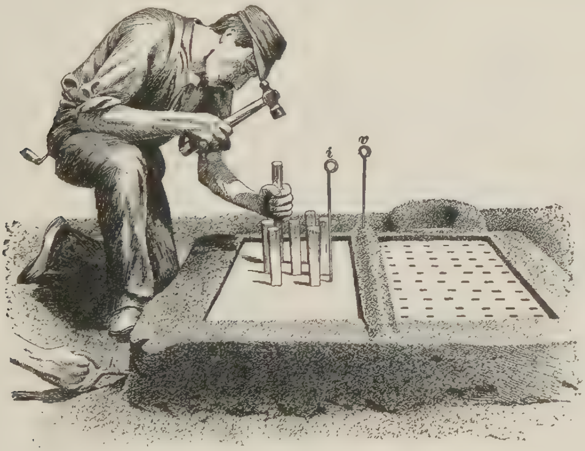


Fig. 7

above the edges of the mold and thus the casting may be made from $\frac{1}{8}$ to $\frac{1}{4}$ inch thicker than the depth of the mold. The thickness of a casting made in an open-sand mold depends on the depth of the mold, the fluidity of the iron, and the judgment of the molder in deciding when sufficient iron has been poured into the mold. It is difficult to make open-sand castings within $\frac{1}{8}$ inch of any specified thickness. In order that the thickness may be as close as possible to that specified, the iron should be very fluid, an overflow should be cut just before pouring at the required height, and pouring should stop as soon as iron starts to run out of the overflow.

10. Venting Beds.—When a number of molds are placed from 8 to 12 inches apart on a soft bed made as described, they will seldom require any venting except when fine grades of sand are used. Where floor space is limited so that open-sand molds must be placed close together, say from 2 to 4 inches apart, it may suffice, where open grades of sand are employed, to drive a row of vertical $\frac{3}{8}$-inch vents down the center of the partitions of sand dividing the molds, as shown at v, Fig. 7. When a bed cannot be vented sufficiently by the methods already explained, an iron rod about $\frac{3}{8}$ inch in diameter and 3 or 4 feet long may be run in horizontally under the bed, as shown at k, after the mold is completed. This may be repeated at a sufficient number of places to provide the necessary outlets for the gases.

11. Beds for Prickered Plates.—A prickered plate is a plate having prickers or prongs projecting from it. It is built into some part of a mold to hold the sand together. Prickered plates are therefore made in sizes and shapes to suit the molds in which they are to be used. The prickers are cast on the plate to give the sand a better support. They may be merely straight prongs placed in a hit-or-miss fashion over the surface of the plate, or they may be placed so as to follow roughly the outline of a depression in the core. Fig. 7 shows molds for two prickered plates, the one on the right being completed and the molder is making the holes for the prickers in the other plate.

12. In making beds for plates having prickers, or prongs, on them, the depth of the tempered sand must be much greater than for plain plates. As an example, the plain plate to be cast in the bed shown in Fig. 6 can be successfully made with a depth of tempered sand ranging from 4 to 5 inches without any venting; but if it should be necessary to have prickers from 4 to 6 inches long on such a plate, the tempered sand should be from 8 to 10 inches deep. The sand is spread on the cinder bed in layers of from 3 to 4 inches in thickness and each layer is packed firmly. If sand were shoveled in loosely, as in the case of the soft bed just described, the prickers or prongs,

if over 6 inches deep, would be liable to be strained at their bottom ends in such a manner as to burst into each other, or to swell at the end so badly as to raise part of the mold, thus spoiling the casting. Some plates require prickers or prongs from 12 to 30 inches deep. It is very difficult to make such deep-prickered plates in open sand without some gas finding its way into or through the plate. This escape of gas is called *blowing*, and results in the production of a defective casting. In some cases it is best to dig deep enough to permit a cinder bed to be placed under such plates, as shown at *C*, Fig. 8, and then to fill in the tempered sand in layers ranging from 3 to 4 inches deep, and vent each alternate layer of sand with $\frac{1}{8}$- or

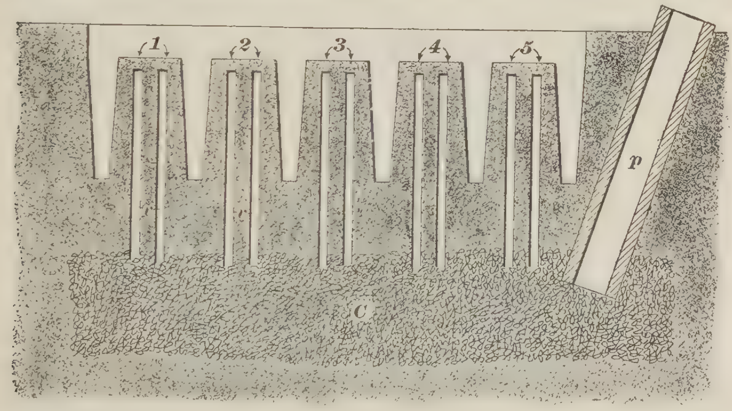


Fig. 8

$\frac{3}{16}$-inch vent wire down to the cinder bed, which is itself vented through the vent pipe *p*. Another plan is to have six or ten pricker patterns, instead of the one or two used in the case of shallow prickers, and to press them all down one after the other, and then, before they are withdrawn from the sand, take a $\frac{1}{8}$- or $\frac{3}{16}$-inch vent wire, as shown at *i*, Figs. 7 and 9, and carefully vent down from the face of the mold to the cinder bed between all the pricker patterns, making the vents about 2 inches apart, as at *v*, Fig. 8. These vents, coming to the surface of the mold, must be stopped up with the end of the finger, and then all the finger holes filled with sand, and the surface slicked over to make the face of the mold smooth, as at *1*, *2*, *3*, *4*, *5*, Fig. 8.

13. In some cases, instead of carrying the gases from these vertical vents through the cinder bed, the venting can be done by using a long $\frac{1}{4}$- or $\frac{3}{8}$-inch vent rod driven in at the bottom of the tempered sand to bring the gases to the side of the bed, as seen by the vent wire *k*, Figs. 7 and 9. In packing the sand by layers or courses in these beds, care must be taken not to make them so hard that the molder cannot push the pricker pattern down by hand to a depth of from 6 to 8 inches. Beyond this depth it may often be necessary to use a hammer to drive the prickers, as in Fig. 7. Another point to be noted in making deep-prickered plates is to use no sand that has not been well tempered and passed through a $\frac{1}{4}$- or $\frac{1}{2}$-inch riddle.

Fig. 9

Care must be taken to work the sand as dry as it can be used and give good results; it must not be so dry, however, that there will be any risk of the sand running back into the holes left by the pricker pattern after it has been withdrawn. The pattern used for making prickers or prongs on plate castings should always have a handle from 6 to 8 inches long and of convenient form for the hand. A good form of pricker pattern is illustrated in Fig. 10, where it is shown as generally held when being pressed into the sand.

Deep-prickered plates usually give trouble at the first attempts, but with some experience in molding them, and by

following the directions here given, they should be made successfully.

14. Hard Beds for Open-Sand Castings.—Castings with lugs or long projections on them may be cast in open-sand molds if it is not of much importance whether the cope, or upper side, of the casting is a little rough. In making such castings, the straightedges are leveled as already explained. Then, tempered sand is filled in and rammed down evenly and firmly to nearly the top of the straightedge, using the butt of the rammer or the feet. When the ramming is done, a straightedge *c*, Fig. 9, with its lower edge cut down $\frac{1}{2}$ inch at each end, is used to strike off the bed so that its surface will be $\frac{1}{2}$ inch below the top of the straightedges *a* and *b*. Then the surface of the bed is vented all over with a $\frac{1}{8}$-inch or $\frac{3}{16}$-inch vent wire, the vents being made about 1 inch apart. These vents may be carried down to a cinder bed or led from under the bed with $\frac{1}{4}$- or $\frac{3}{8}$-inch vents leading from under the straightedge, as shown by the vent wire projecting at *k*. After the surface of the bed has been well vented, the palm of the hand is passed over it to close up the top of the vent holes. Riddled sand is then shoveled on to about $\frac{1}{2}$ inch higher than the top of the straightedges *a* and *b*. Pieces *d* and *e*, about $\frac{1}{4}$ inch thick, are now used in conjunction with the straightedge *c*, to strike off the bed as shown in Fig. 3, and the bed is then rammed with a butt rammer. If the sand sticks to the rammer, the end of the rammer should be warmed. The bed is then struck off with the seesaw motion already described. The layer of riddled surface sand is thus left smooth, even with the straightedges and adhering firmly to the sand in the bed so that it will not float when iron is poured into the mold.

FIG. 10

HARD BEDS FOR COPED MOLD

15. Making the Bed.—Large surfaces covered with a cope permit harder beds being used without causing the blowing of the metal and the making of scabs than can be used for open-sand work. In making these beds, the sand should be as dry as can be easily worked and should be vented as well as possible. The operations, so far as leveling the straightedges is concerned, are nearly the same as those described in connection with Figs. 1 and 2, the only difference being that the straightedges *a* and *b* will be set down into the floor so that their top edges are about the thickness of the casting below the floor. After the straightedges are leveled, sand that has been well tempered and riddled is filled in between them and struck off level with their top edges; the sand is rammed down with the feet as far as possible and then the whole surface of the bed is rammed with the butt of the rammer. The rammed sand will thus be brought down to about 2 inches below the top of the straightedges when they are about 6 inches deep, which is about as deep as such a course should be. The sand having been butted solidly, common sand is again shoveled in and struck off to the level of the top of the straightedges. It is then butted down lightly all over the bed and a straightedge *c*, Fig. 9, whose ends are cut down $\frac{1}{2}$ to $\frac{3}{4}$ inch, is used to strike off the bed, which is then closely vented all over the surface with a $\frac{1}{8}$- or $\frac{3}{16}$-inch vent wire.

The tops of the vent holes may be closed by combing the surface of the bed with a card made by driving nails about $\frac{1}{2}$ inch apart through a board so that they stick out about $\frac{1}{2}$ inch all over the face of it. This combing roughs the surface of the bed, which should then be covered with facing sand, passed through a $\frac{1}{4}$-inch riddle, to a depth of about 2 or 3 inches above the straightedges. The sand is tramped down or butt rammed and struck off level with the top of the straightedges. A little facing sand is then riddled on and the surface is again struck off, this time the seesaw motion described in connection with Fig. 5 being used. The surface is thus made smoother and more uniform than when struck off the first time.

16. When the bed has been completed, a little fine parting sand is put on where the pattern is to be placed so that the sand will not stick to it; the pattern is put in place and held down with weights. Heap sand is piled around the pattern to a depth of from 3 to 4 inches above the top and peen rammed around it, keeping about $1\frac{1}{2}$ inches from it so as not to strike and injure its edges. Heap sand is then put on where the peening was done and the whole is tramped and butt rammed. The joint is now made wide enough to extend beyond the edges of the cope, parting sand is sprinkled on the joint and pattern, and the cope is rammed up. The cope is then lifted off and a trench is dug around the mold to permit venting the bed. Loose sand is removed from the trench, and the side next to the mold is patted smooth with the hand, and it may be wetted slightly if necessary to retain the sand in place. The bed is now ready to be vented; but the pattern is first weighted, to avoid all danger of moving it while venting the bed. The bed is vented by means of iron rods that are long enough to reach at least halfway across the mold. When the bed is vented, the pattern is drawn, the cope, which has been vented in the usual way, is replaced, and the mold is ready to be poured.

17. Surface Venting.—Where beds are desired with very hard surfaces, or where the sand is of such a nature as to readily cause the formation of lumps or scabs on the surface of the casting, it is a good plan to bring the vents as close to the surface as practicable. The following is a plan for making the bed and venting close to the surface. Such a bed as this may be vented from the side, as was explained in connection with Figs. 7 and 9, or a cinder bed may be used and the vents from the surface of the bed run down to the cinders, in which case this plan may be employed. It consists in ramming up solidly and striking off the common sand within about $\frac{3}{4}$ inch of the top of the straightedges, Fig. 9, and then covering the surface of the bed with facing sand mixed with powdered coal, called sea coal, so that it projects about $1\frac{1}{4}$ inches above the top of the straightedges, using pieces $1\frac{1}{4}$ inches thick under the

straightedge *c*, as shown at *d* and *e*, Fig. 3. After this is done, a butt rammer is used over the entire surface, in the manner illustrated in Fig. 11. In butting the surface of such a bed, the operator must make sure that no part of the surface is missed and the butt rammer must be applied lightly so as not to make the face of the bed too hard. To insure a smooth

FIG. 11

surface to the bed, no sand should be allowed to stick to the face of the butt when ramming; a brass butt may be used or the end of the rammer may be warmed.

18. After the sand has been butt rammed, it should project about $\frac{1}{2}$ inch above the straightedges. The surface of the bed is then vented with a $\frac{1}{8}$-inch wire, the holes being placed about 1 inch apart and the vent wire driven down to the cinder bed. If there is no such bed, then $\frac{1}{4}$- or $\frac{3}{8}$-inch vent rods, set horizontally, as at *k*, Figs. 7 and 9, must be used. After the venting, the bed is struck off in a seesaw manner, as already described, and facing sand sifted all over its face as thinly as possible.

This process completed, a hardwood finishing block is worked all over the face of the bed to make it smooth and ready for finishing with the trowel. The application of the smoothing block not only gives a finish to the surface of the bed, but it also assists in firmly stopping up the the top ends of the vent holes, preventing iron from bursting into them, keeping confined gas from forcing its way through the holes into the mold, breaking the face of the mold and causing scabs. In some cases where there is extra danger of scabs being produced, the reliability of the bed may be increased by first venting it with a $\frac{1}{4}$-inch vent wire, as shown in Fig. 9, before the $1\frac{1}{4}$ inch depth of facing sand is shoveled on. When this latter plan is used, the vents from the face, made with a $\frac{1}{8}$-inch vent wire, need not extend to the cinder bed.

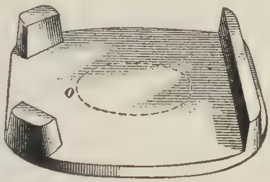


FIG. 12

19. The casting shown in Fig. 12 might be cast on either a hard or a soft bed. If the casting is not too large and the projections are not very long, a soft bed may be used; but if the casting is large or the projections are long, it would be better to use a hard bed. When bedding such a pattern in a soft bed, the following method may be followed:

FIG. 13

The pattern is first set on the bed and pressed down so as to leave an imprint of its projections; it is then removed and the greater part of the sand where the lugs came is cut away with the shovel, after which a trowel is used to take out the sand to within about $\frac{1}{4}$ inch of

the inside of the imprint. The bed is left as shown in Fig. 13. The pattern is next set back and hammered down solidly on the bed, the molder striking on a block, as shown in Fig. 14;

Fig. 14

after this, sand is rammed up against the outside of the lugs and the edges of the pattern and the mold vented, as illustrated at *k*, Fig. 15. Next the pattern is drawn and the mold finished ready for the metal, as shown. It is of special importance that a block of wood or a heavy plank be used to pound on when bedding in patterns; no sledge or heavy hammer should be used on the bare face of a pattern.

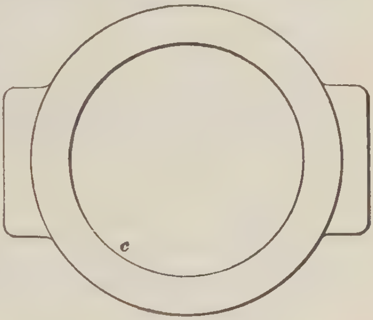
20. A deeper bed may be made in the following manner: A pit is dug large enough to have a space 1 foot wide all around

Fig. 15

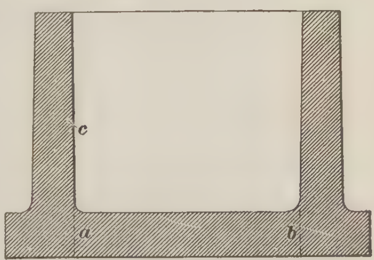
the pattern and having a depth from 16 to 18 inches greater than that of the pattern. The bottom of the pit should then be carefully examined for soft spots, which should be filled and

tamped if found. The bottom of the pit is then rammed all over and a layer of cinders from 4 to 6 inches in thickness is spread on it. The cinder bed is butt rammed all over and pipes are placed at various points around the edges of the pit extending from the cinder bed above the surface of the molding floor. A small quantity of cinders should be placed around the bottom of each of the pipes to prevent their being stopped up when the sand bed is put in place. A layer of sand, from 5 to 6 inches in thickness, is now spread on the cinder bed and peened and butt rammed until it is hard. This operation of filling sand and ramming should be repeated until the tops of straightedges laid on the surface of the sand are nearly even with the foundry floor. The straightedges are then put in place and leveled up and the bed finished as explained in Art. **14.**

21. Mold with Green-Sand Core.—Many molds have bodies of sand, called green-sand cores, extending upwards from the bottom of the mold. These cores are not covered with metal until the mold is nearly full, and special care must therefore be taken to hold them down. The casting shown in Fig. 16, when cast upside down, is an example of this class of work. The pattern is, however, not exactly like the casting, because it has no bottom. The inside of the pattern is extended through the bottom as shown by the dotted lines *a* and *b* in line with *c*, in (*a*). The hole in the bottom of the pattern assists in the molding of the core, which could not be rammed if the pattern were solid.



(*b*)



(*a*)

FIG. 16

The body of the mold is shown in Fig. 17 and a section in Fig. 18. Part of the mold is cut away at *a*, Fig. 17, to show the core. The cope is not shown in either illustration. When

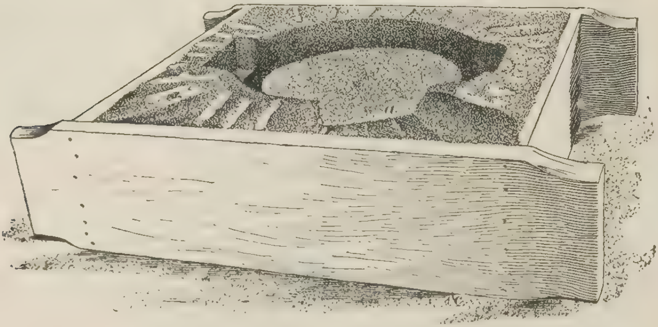


FIG. 17

the mold is poured, the core will be covered with metal, which will extend down to *b*, Fig. 18, and the core must therefore be

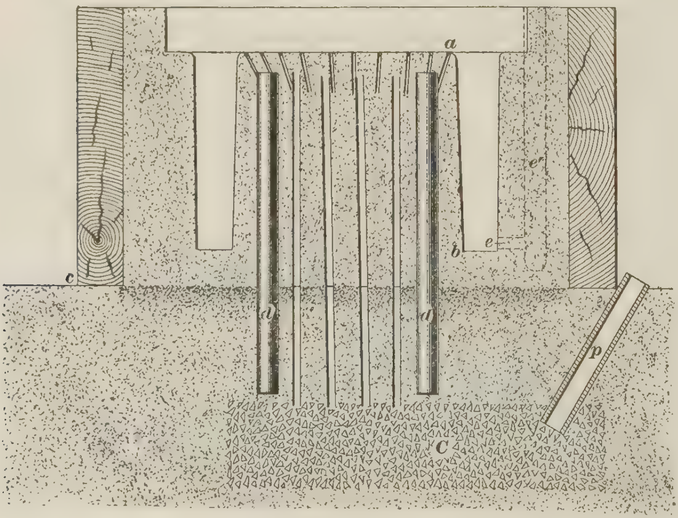


FIG. 18

vented through the bottom. To provide for the venting, the mold is made over a cinder bed *C*, Fig. 18, from which pipes *p* extend above the floor level outside of the flask. The depth of

the cinder bed below the flask depends on the size of the mold; the larger the mold, the farther the cinder bed should be from it. Sand is then filled in and rammed until the top of the pattern, when resting on the sand, is about even with the top edge of the flask.

22. Such a core might be lifted when the mold is poured if the strength of the sand alone held it down. When it is desirable to avoid the use of chaplets, this kind of a core may be held down by rods *d*, Fig. 18. This method of holding down cores will be explained more fully under Rodding Cores. These rods are now driven in so that their top ends are not less than $\frac{3}{4}$ inch from the top surface *a* of the core. A dry-sand core having a hole through it is put in at *e* for the gate and the sprue pin is set in at e'. The sprue pin must be long enough to reach through the cope when it is rammed up. The mold is then filled with sand and rammed both inside and outside of the pattern, each course of sand being made softer than the one below it, and the joint is made even with the top of the pattern. After the cope has been made and vented, the sand is dug out inside the pattern to the required depth and the top of the core is ready to be finished.

23. The gases in the core tend to rise and pass out through the surface *a*; but if this were permitted the casting would blow and be defective. To prevent the blowing, the surface at *a* is made as soft as practicable and the large vents not brought nearer than within $\frac{3}{4}$ inch of the top surface of the core. This work is done by digging the sand from the inside of the pattern and then striking it off with a straightedge cut away at the ends, as in Fig. 9. The bed having been struck off $\frac{3}{4}$ inch below the surface of the core, a $\frac{1}{4}$-inch vent rod is used to vent closely all over the area down to the cinder bed *C*, Fig. 18. The tops of these vents are then stopped up with the end of the finger, a very open grade of facing sand shoveled in over them, and pressed down with the fingers and palm of the hand as softly and evenly as can be done. This lightly packed sand should extend about $\frac{3}{8}$ inch above the level of the face at *a*, so that the top of the sand may be struck off to give a smooth and finished

face to the core. Before striking off this extra sand, the face is closely vented with a fine wire, about $\frac{1}{16}$ inch in diameter, to a depth of about 3 inches, thus connecting the face vents with the large $\frac{1}{4}$-inch vents, as shown in Fig. 18. The $\frac{3}{8}$ inch thickness of sand is struck off and the surface finished with a trowel, leaving the top of the core as it appears at *a*.

Molds of this kind can be made in pits and large molds had better be so made, in order to avoid the danger of having the metal run out on the joint *c* between the flask and the foundry floor.

24. Rodding Cores.—Where cores project from the bottom of the mold, as shown in Figs. 17 and 18, they must be rodded to make sure that the buoyancy of the metal will not lift them. In the casting illustrated in Fig. 18, six $\frac{3}{8}$-inch round rods, as shown at *d*, are *clay-washed* or covered with flour paste to make the sand stick to them, and then driven at equal intervals around the core to the depth shown. In the hands of a good molder this core may stand without rodding; but it is always advisable to take as few chances as possible. The question as to whether it is wise or not to rod a core in this manner is often one of judgment, as the condition of the patterns, flasks, and sand often has much to do with determining what plan it is best to follow. All material that is lighter than liquid metal will rise to the top and float. Sand is lighter than iron and for this reason, if the core is not held down, the iron may get under it and cause it to float.

25. Taking bulk for bulk, 1 cubic foot of iron weighs about 450 pounds, whereas 1 cubic foot of rammed sand weighs about 100 pounds, the weight of the iron thus being about $4\frac{1}{2}$ times that of rammed molding sand; therefore, a core of rammed sand, such as that seen in Figs. 17 and 18, would have to be about $4\frac{1}{2}$ times heavier than it is before it would remain in position as molded were it not assisted by other forces. One of these aids is the adherence of the tempered and rammed sand which prevents it from being readily separated. This principle is illustrated in the necessity for using parting sand on slicked joints, in order to separate the sections of molds,

as previously described. This adherence in the sand of the core would leave but little risk if the rods at *d* were omitted in this special casting, provided it was well rammed at the bottom. This point is where the danger lies with all such work; any softness at the lower edge of such cores as this one allows the metal to undermine the core, and if the metal once gets underneath it, it will rise unless held down by rods or some other means. Then, again, it is necessary to guard against these cores being loosened at the bottom when rapping the pattern to draw it from the mold. Still further, patterns are often deficient in taper or draft, so that in trying to draw them, the whole core may be started or lifted from the bottom and so leave an opening for the metal to pass under. If any doubt exists as to the safety of a core, it is better to use the rods *d*, and so prevent possible loss of the casting. No positive rule can be given for such work, but a study of the principles here outlined, together with his knowledge of the work, will enable the molder to decide correctly in any given case.

26. Draft on Patterns.—In the last article, reference was made to the danger of starting cores at the base, owing to a lack of draft on the patterns. As a rule, a pattern should have all the draft that can be allowed. The greater the draft, the less labor will be required in finishing the mold and also the longer the pattern will last. The deeper a pattern is buried in the mold, the more draft it should have. In cases where the bottom of a deep casting must be of nearly the same thickness as at the top, the draft of the pattern must be made accordingly. Ordinarily for cast iron, a draft of $\frac{1}{16}$ inch per foot is allowed. Where the conditions are not exacting, however, it would be much better to double this allowance, thus giving $\frac{1}{8}$ inch per foot for whatever depth the patterns might be rammed in the sand. In designing work calling for such cores as are shown in Figs. 17 and 18, every effort should be made to have not less than $\frac{1}{8}$ inch per foot of draft on the

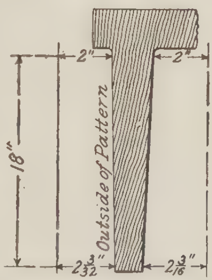


FIG. 19

inside. Such a pattern would, therefore, have its top and bottom dimensions as shown in Fig. 19, if the length of core were 18 inches, as indicated. It will be noticed that $\frac{1}{16}$ inch per foot is allowed for the outside draft and $\frac{1}{8}$-inch draft for the inside, where the extra draft is most needed. Not only should patterns have good draft, but they should also be well provided with arrangements for drawing the pattern. In deep patterns, this calls for drawplates which are screwed to the tops of the patterns.

27. **Drawing Deep Patterns.**—Where a deep pattern is used to give parallel castings, or where there would be difficulty in getting a pattern out of the sand, it is sometimes necessary to draw it with a crane. The pattern should be raised very evenly. If one side is drawn faster than the other, it not only causes the pattern to bind in the sand which may injure both patterns and the mold, but in the case of molds having cores, there is great liability of starting the cores from their bases, even when they are well rodded. Starting the base might permit the iron to pass in at the line of separation and so into the vents, even though it did not lift the whole core. To have the iron run into the vents at the base of the mold is as bad as lifting the whole core, for in either case the casting will be lost.

CLAMPING AND WEIGHTING THE MOLD

BUOYANCY

28. **Lifting Pressure of Molten Metal.**—When the molds have been closed, it is necessary either to clamp or weight down the copes, to resist the lifting force of the metal. This fact is readily understood when it is considered that a liquid will support a body lighter than itself. Sand is lighter than iron and for this reason the cope will float on the surface of that metal, unless it is held down. The actual force required to hold a cope down depends on the height of the column of molten metal—that is, the head pressure, the weight of the

cope that is liable to be floated by the metal, and by the size of the core and the depth to which it is submerged in the metal.

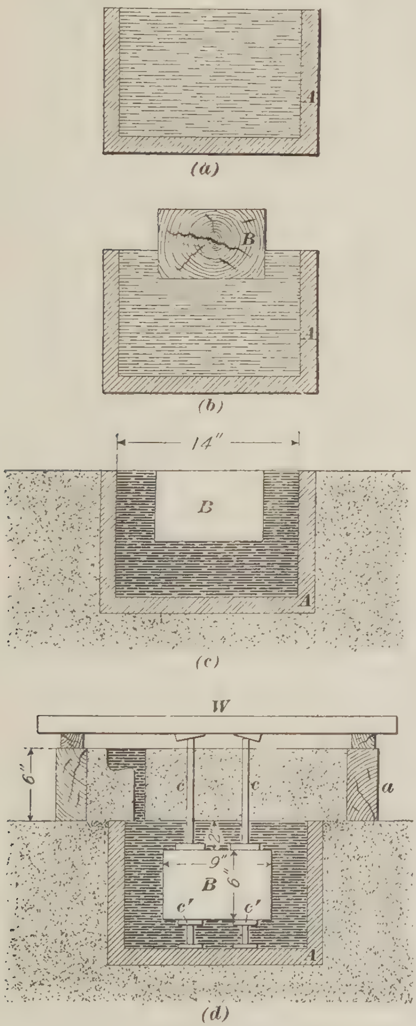


FIG. 20

To make this subject as plain as possible, suppose that A in Fig. 20 (a), is a tank instead of a mold and has been filled with water to its top, as shown. If the block of wood B is placed in this tank, as shown in (b), the water will run over its sides until the block comes to rest. If the water that ran over the sides were collected and weighed, it would be found to equal the weight of the block B. In other words, this block, in coming to rest, sank to such a depth that it displaced a body of water equal to its own weight. If it was desired to sink this block B to the level of the top of the tank, as shown in (c), sufficient weight would be required on the block to equal the additional weight of the water that would be displaced by the block sinking to the depth shown.

29. Carrying this illustration still further, it might be desired to submerge the block, as in Fig. 20 (d). Very little additional weight would

be required, because as soon as the block was just covered, the weight of the water above it would be practically the same as the extra amount displaced below the block. This experiment illustrates the principle involved in weighting down cores or copes, the principle being the same both for water and for liquid metal. The only difference between the two is that if the block B were a core submerged in liquid iron, more weight would be required to hold it down, because iron is heavier than water. A cubic foot of pure water, at a temperature of 60° F. weighs about $62\frac{1}{2}$ pounds, and 1 cubic foot of ordinary gray cast iron about 450 pounds.

30. Submerged Cores.—Suppose the liquid to be molten iron instead of water and that the cope a, Fig. 20 (d), is placed on top of the mold; find the weight W that would, by means of chaplets c, keep the core B from rising. The weight is computed in the following manner: Assuming the core to be 24 inches long, 9 inches wide, and 6 inches deep, and its ends to be free, its volume is $24 \times 9 \times 6 = 1{,}296$ cubic inches. A cubic inch of cast iron weighs about .26 pound; hence, the weight of the iron displaced by the core is $1{,}296 \times .26 = 336.96$ pounds. The weight of the core itself is $1{,}296 \times .06 = 77.76$ pounds, .06 pound being the weight of a cubic inch of rammed sand. The buoyancy of the core is therefore the difference between these two amounts, or 259.2 pounds, which is the weight required to keep the core from rising.

If the core were supported by prints instead of being free at its end, its additional length and the sand over the prints required to stop them up would also have to be deducted from the 259.2 pounds. As the core in the present case is supposed to be held up by the chaplets c', the whole weight of the core has been considered. Having found the weight necessary to hold down the core, the next step is to find the weight of the cope.

31. Weighting the Cope.—The weight required to hold a cope down together with a core bearing against its lower surface will now be found. Let the cope measure 34 by 24 by 6 inches above the surface of the metal and let the core be

24 by 9 by 6 inches submerged 2 inches as shown in Fig. 20 (*d*). The weight of the cope is found by multiplying its volume in cubic inches by .06, thus: $34\times24\times6\times.06=293.76$ pounds. This weight is sufficiently accurate when a wooden cope is used, but when an iron cope is used it would be necessary to find the weight of the cope and add it to that of the sand. The weight required to hold the core down was found in Art. **30,** so the weight to hold the cope and core down may now be computed. In this computation first find the area of the cope-casting surface; this area is 24 inches$\times$14 inches$=$336 square inches. This product is multiplied by 6, the height in inches of the head or gate, giving 336 square inches$\times$6 inches$=$2,016 cubic inches. This result is multiplied by .26, which gives $2{,}016\times.26=524.16$ pounds, the fluid pressure tending to raise the cope. Deducting from this weight the weight of the cope, gives 230.4 pounds as the weight necessary to hold down the cope alone. Adding to this the weight necessary to hold down the core, we have $230.4+259.2=489.6$ pounds, the total weight to be placed on the cope in Fig. 20 (*d*).

32. Partly Submerged Core in Contact with Cope. There are cases where the cores are only partly submerged, their upper surfaces being in contact with the cope, as in Fig. 20 (*c*). In calculating the pressure on such a partly submerged core, the area of the lower surface of the core and also the area of that portion of the cope that has metal beneath it must be computed. Each of these areas is then multiplied by the height above the cope surface or the bottom of the core, as the case may be, of the highest point to which the metal may rise in pouring the mold.

In the case of a core submerged as in (*c*), and intended to be covered with a cope, as in (*d*), the computation is as follows: The lower surface of the core has an area of $24\times9=216$ square inches. Multiplying this by 12, the height in inches from the bottom of the core to the top of the pouring basin, gives 2,592 cubic inches, which multiplied by .26 equals 673.92 pounds, which is the upward pressure on the core. From (*c*) it is found that the width of the cope having metal in contact with it

is 14−9=5 inches; the portion of the cope surface in contact with the metal is therefore 24×5=120 square inches, which multiplied by 6, the height of the cope, equals 720 cubic inches, and this result multiplied by .26 gives 187.2 pounds as the upward pressure on the cope. This amount added to 673.92 pounds gives 861.12 pounds as the total upward pressure. Deducting from it the weight of the core and cope leaves 861.12 −371.52, or 489.6 pounds as the weight to be placed on the cope.

33. Chart Method of Computing Weight for Cope and Core.—The weight required to hold the core and cope down may also be found by the following method: Assume the same core and cope as in the previous example; the core being 9 inches wide, 24 inches long, and 6 inches deep, and the

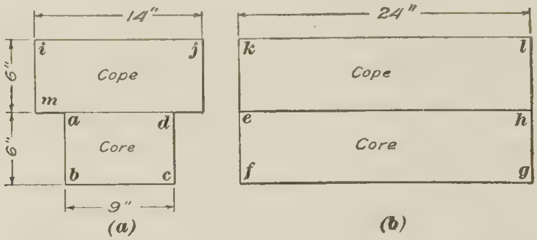


Fig. 21

surface of the cope that is in contact either with the metal in the mold or with the core is 14 inches wide and 24 inches long, and the cope is 6 inches thick. A chart like that shown in Fig. 21 is first drawn. The part *a b c d* in (*a*) representing an end view of the core, is made 9 inches wide and 6 inches deep. The side view of the core is shown by *e f g h* in (*b*), in which *f g*, the length of the core, is 24 inches. The part of the chart above the core represents the part of the cope that is directly over the mold. The mold is 14 inches wide, so *i j* is 14 inches and the length *k l* is the same as that of the core; but if the mold had been longer than the core, *k l* would have been the length of the mold. The height *i m* is the thickness of the cope, but if an elevated pouring basin is used, the height *i m* would be the thickness of the cope plus the height of the pouring basin above the surface of the cope.

The weight required on the cope may now be found by calculating the weight of a block of metal of the size and shape represented by the chart and subtracting from this weight the combined weight of the core and cope. The volume of such a block as that in Fig. 21 is $24\times(14\times6+9\times6)=3{,}312$ cubic inches, which multiplied by .26 gives a weight of 861.12 pounds. Deducting 371.52 pounds, the weight of the core and cope, gives 489.6 pounds as the weight to place on the cope, the same result as by the former method. This method of drawing a chart block of the lifting surfaces and calculating therefrom the weight to put on the cope is a very convenient one and is the one that is adopted when computations are made from drawings.

34. General Rules.—To find the weight necessary to hold submerged cores down, first compute the volume of the core and multiply it by .26; then deduct from this the weight of the core. In other words, the lifting or static pressure on a submerged core is the number of pounds of iron it displaces minus the weight of the core.

To find the weight in pounds required to hold a cope down, multiply the lifting surface of the cope by the height of the head above this surface and the product by .26.

The approximate weight required to hold a cope down may be calculated by drawing a diagram similar to that in Fig. 21, but having the same width as the mold for the whole depth. The weight of this block of metal less the combined weight of the cope and core is the approximate weight required on the cope.

35. Extra Weight Required on Cope.—While it is true that the foregoing rules for weighting down copes, etc. will give just the weights required under the simplest conditions, there are other conditions affecting the results that must be considered and that will often demand more weight than that given by the rules. This requirement is due to the fact that there is an instant when the metal comes up suddenly against the lifting surface, during which a sudden pressure is exerted that is greater than that due to the height of the head, the latter being merely the steady pressure that will be exerted by the liquid when at rest. When pouring a mold, it generally takes

from 10 to 50 seconds and sometimes more to fill it with metal, whereas, when the mold itself is filled the pouring gate may fill in less than a second, thereby obtaining a head pressure in a moment's time that, owing to the suddenness of its creation, may in some cases be so great as to call for from one-fourth to one-third more weight than the static head pressure obtained by the rules just given. The higher the top of the pouring gate is above the cope's lifting surface, the greater will be this extra pressure.

Then, again, some molds will be poured with more than one ladle, and the more ladles used, the greater will be the pressure, because of the increased pressure created by the metal as it flows from the ladle directly into a gate, as shown at *e*, Fig. 22.

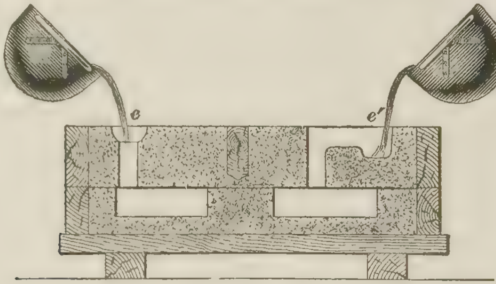


FIG. 22

This increased pressure may be equivalent to the pressure of a head of from one-fourth to one-third the height of the ladle's lips from the top of the gate. If the pattern is gated and poured as shown at *e′*, less weight will be required to hold down the cope than if poured in the manner shown at *e*.

36. Momentum Lift.—In addition to the weight rendered necessary by the head-pressure, extra weight is required to allow for the momentum lift caused by the sudden stopping of the flowing iron at the moment the mold is filled. The amount of this lift depends, briefly, on the character of the pouring system, the speed of pouring, the number of ladles, and the square inches of lifting area that the metal will suddenly rise against, as well as the height of the pouring gate or flow-off risers above the face of the cope's lifting surface. Enough

has been said to demonstrate the wisdom, and often the necessity, of placing more weight on a cope than is called for by the head pressure, and the molder must exercise good judgment in this matter.

37. Effect of Dull Iron on Buoyancy.—The lifting force of the molten metal depends in a measure on whether it is hot or dull. If the metal is dull, in most cases it will exert less pressure than if it were hotter and therefore more fluid. On the other hand, the duller the iron is, the more apt it is, in molds having risers or flow-off gates, to have its pressure approach that due to the pouring basin's height, which is generally higher than that of the top of the risers or of the flow-off gates. Often the metal will *freeze* at the entrance to the risers, or it may come up the risers so sluggishly as to retard the flow of metal out of them and so cause the head pressure to approach that due to the height of the pouring basin. In the case of thin castings, if the metal is dull enough to freeze in the risers, it is not very apt to exert a great lifting pressure on the mold. If, with thick castings, the risers or flow-off gates should freeze up or flow sluggishly, there will be exerted a lifting pressure due to the full height of the pouring basin's head.

38. Computing the Static, or Head, Pressure.—Some molders compute the head pressure on the cope by taking the height from the top of the riser or flow-off gate, the top of which is often located from 4 to 6 inches below the level of the top of the pouring basins or gates. This practice is rarely a safe one, as risers or flow-off gates may solidify or be blocked up so that the metal cannot flow freely through them. If it were always possible to count on having hot iron and enough room in the risers or flow-off gates to carry off the metal as fast as it could be poured into the mold, the height of risers would then, as a general thing, determine the pressure. Nevertheless, the safe plan is to figure from the highest point it is possible for the metal to reach in the pouring gates or risers and then allow extra weight on the cope.

39. Weights for Holding Down Copes.—In weighting down molds, many founders use pig iron piled in separate pigs

on the cope, or else place the pigs in stout wrought-iron rings, to be hoisted into position by a crane. Others, improving on this practice, cast bars ranging from 1,000 to 2,000 pounds in weight and from 3 to 6 feet in length, with hooks cast in them for convenience in handling with a crane. Other foundries preserve bad castings or take lumps of heavy scrap iron for flask weights and handle them in the best way they can. When flask weights are required, it pays in the end to have them as handy in form and size as possible; this statement refers to weights for medium and large castings. For small castings, light weights for snap flasks, etc. are required; these latter are generally made from 1 to 1½ inches thick and of a size to cover the entire surface of the cope, if they are not burdensome for one man to handle. These weights generally have holes in their centers and outer corners for pouring through, as shown in Fig. 23, which illustrates a section of a weight *w* and a mold. The under surface of these weights should be as smooth and true as they can be cast. A snap flask rarely requires more than one such weight.

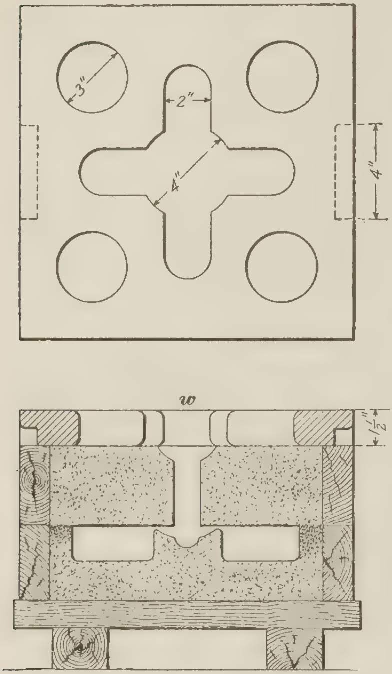


FIG. 23

CLAMPS FOR FLASKS

40. Types of Clamps and Their Uses.—Shops that do much roll-over work should have a number of clamps which are adapted to their needs. These clamps are made both of

cast and of wrought iron and should be as handy in size and form as conditions will permit. Clamps of the forms generally used in rolling over the drags and in holding flasks together

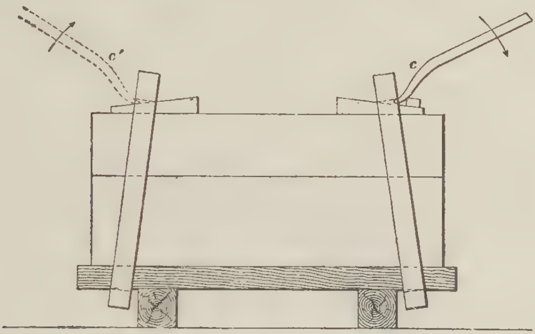


FIG. 24

when a mold is being poured are shown in Figs. 24 to 26. Many patents have been taken out for improvements in clamps; the chief features of these are that their length can be changed or they can be used without wedges. In clamping a flask preparatory to casting, it is not safe to drive in wedges with a hammer, as the cope may be jarred, causing the sand to drop. As a rule, flasks should be clamped by means of a clamping iron, as shown at c, c', Fig. 24. The clamping irons are made with wedge-shaped points, so as to enter the small openings between the cope and clamp and to give good leverage in either direction, as shown by the arrows. These clamping irons are, as a rule, made of old files, the points of which are turned up and sharpened.

41. In Fig. 25 (*a*) a wrought-iron clamp is shown and in (*b*) a cast-iron clamp such as is commonly used

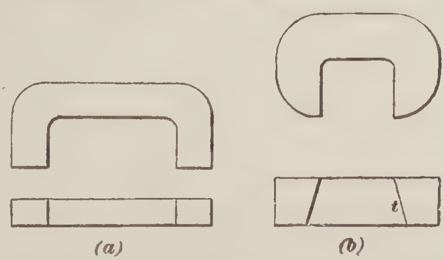


FIG. 25

for clamping flanged flasks like those illustrated in Fig. 26. Such flasks are generally used for dry-sand molding. Cast-iron

clamps are usually tapered on the inside to permit of their being molded, the taper being shown, somewhat exaggerated, at *t*, Fig. 25 (*b*). In placing clamps on the flanges, they should be set so that the wedge will enter them at their largest side, as at *c*, Fig. 26, which shows the wedge about to enter the space between the clamp and the flange of the iron flask; when driven, it should appear as shown at *d*.

Molders frequently try to clamp flasks by driving wedges at the top of the clamps, as shown at *e*. This practice is wrong; for by trying to drive a wedge in at the top, the weight of the clamp must be lifted, and in lifting a constant jarring takes place, making it difficult to get the clamp to a solid bearing.

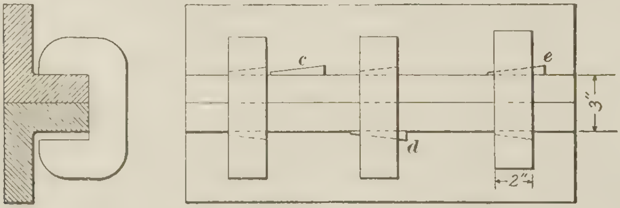


Fig. 26

Not only is it difficult to tighten a clamp by top wedging, but too much time is required.

42. Strength of Clamp.—Where the work is such that the clamps must resist a heavy pressure, as in the case of casting rolls, pipes, etc. on their ends in dry sand, the wrought-iron clamp should have the preference, as cast-iron clamps are not to be relied on in such work. Owing to the breaking of cast-iron clamps, castings have often been lost and men have been burned.

The proper thickness for clamps can be obtained by figuring the pressure on the flasks to be held together and then deciding the distance apart that the clamps will be set along the flange of the flask. Knowing the thickness, and allowing a stress in the clamp of 15,000 pounds per square inch for good wrought iron and 5,000 pounds per square inch for good cast iron, a very good idea can be formed as to the proper thickness for clamps.

43. Floors for Holding Down Copes.—Many foundries that handle a standard class of work which can be bedded in have a part of the floor area dug to a depth of from 3 to 6 feet, according to requirements, and then place iron beams or binders in the bottom of the pit, about 3 feet apart. A plank flooring is formed over the top of these binders; from the ends of the binders wrought-iron straps or bolts are run up to the

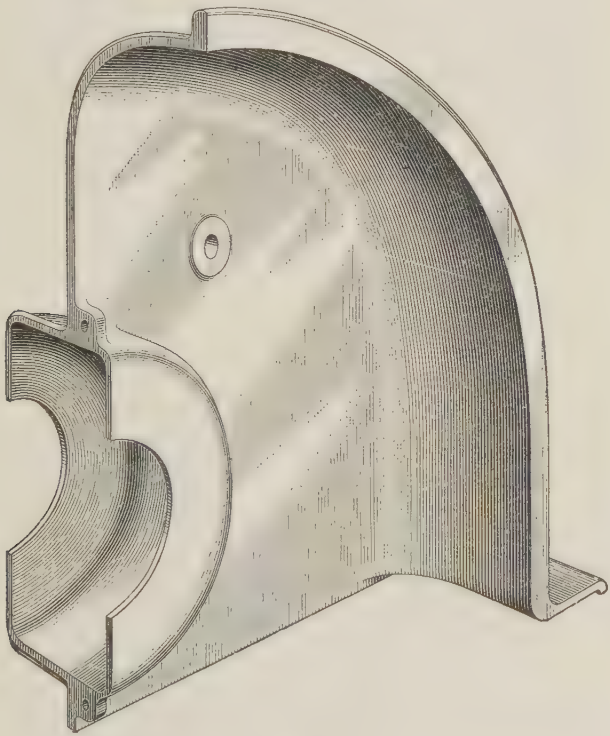


FIG. 27

level of the floor. This pit is then solidly rammed with sand to the level of the floor, after which the holes are dug out for molding the patterns. The molds are made after the usual manner, and binders are placed across the top of the cope directly over those in the bottom of the pit; after which bolts are extended from the top binders to connect with those extending

from the bottom ones so that the cope cannot be raised by the pressure of the molten iron. The practice of using these bolting-down floors instead of weights is a good one.

MOLDING EXAMPLES

44. Large Match-Plate Mold.—The shield shown in Fig. 27 is somewhat large, it being approximately 6 feet by 5 feet and 2 feet deep, but only $\frac{1}{2}$ inch thick. Fig. 28 shows two views of the shield, (*a*) being an outside view and (*b*) an end

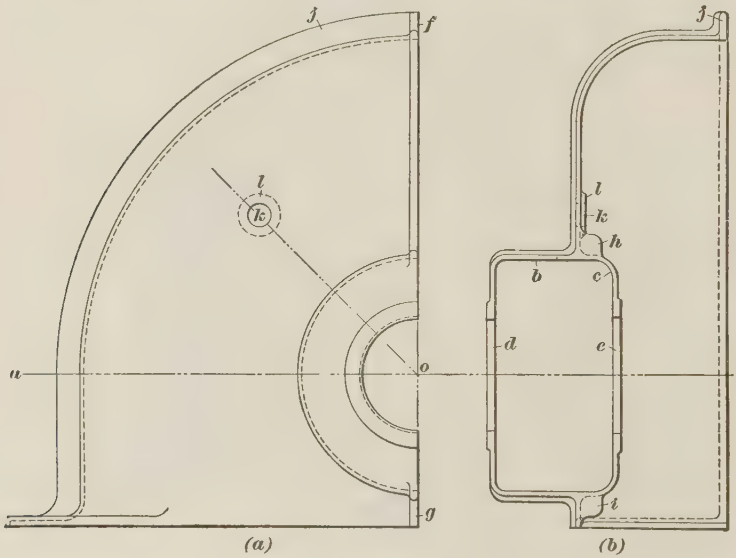
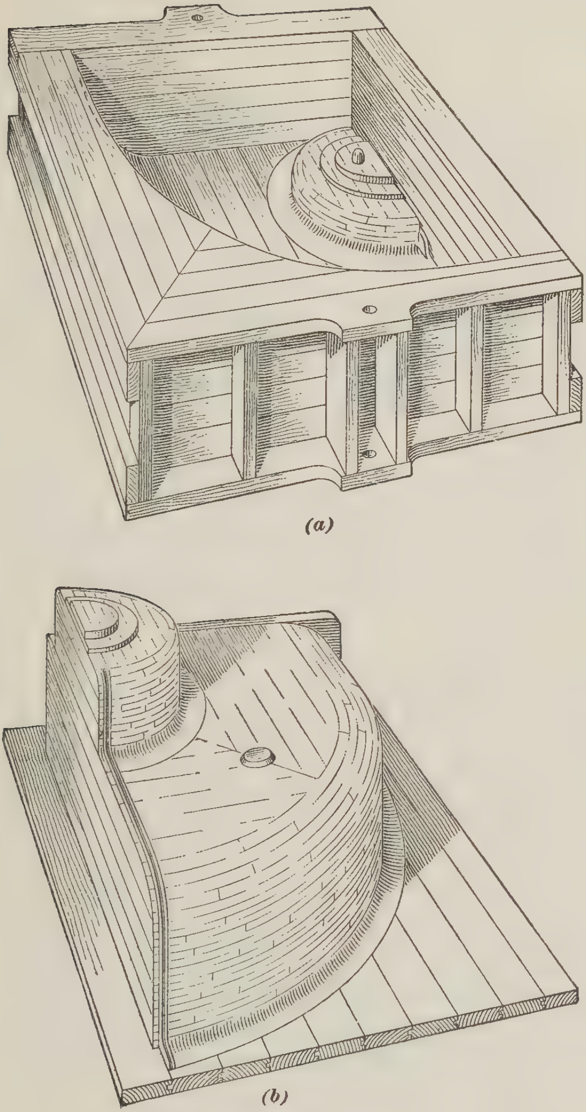


FIG. 28

view looking into the casting. The hub shield is divided into two parts, the part *b* lying outside the main shield and the part *c* lying inside it. The holes *d* and *e* are the only openings into the hub shield when the other half of the casting, which is a duplicate of the one shown, is bolted to this casting along the joint surface *f g*. There are two lugs *h i* in which holes are to be drilled to bolt the two castings together. The flange *j* also has holes drilled for bolts to fasten this shield to some part of the machine to which it belongs and there is a hole *k* through



(a)

(b)

Fig. 29

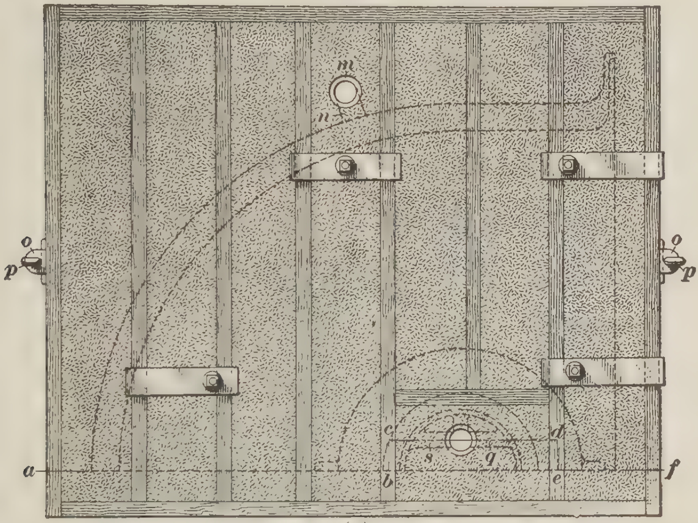
the side of the shield in the center of the boss *l* on the line half way between *a o* and *o f*.

Owing to the large size of this shield and the thinness of the metal, it is impossible to make a single pattern to mold it. The use of a thin pattern may, however, be avoided by making separate patterns for the outside and inside surfaces. The pattern for the outside surface is built on a match board on which the drag will be molded and the pattern for the inside surface is built into a pattern board on which the cope will be molded. In order that the cope and drag molds shall be in the proper position with respect to each other, properly located holes for flask pins are drilled in the match board and pattern board. The match board for the molding of the drag is shown in Fig. 29 (*b*) and the pattern board for the cope is shown in Fig. 29 (*a*).

Two views of the completed mold are shown in Fig. 30, in which (*b*) is a section of the mold along the line *a*, *b*, *c*, *d*, *e*, *f* in (*a*). The green-sand core *g* is suspended from the cope and the dry-sand core *h* that forms the inside of the hub shield is supported in core prints *i*. The sprue *j* is formed through the core and passes down to the bottom of the hub shield. When placed in the cope, the sprue pin must be set so that the hole through the cope will meet the one through the core.

45. The drag is molded by placing the match board shown in Fig. 29 (*b*) on a flat bed that will support the board at all points and the drag flask is set on it, and filled and rammed in the usual way. A bottom board is clamped on and the drag is rolled over, after which the pattern is drawn by lifting the match board. The molding of the cope is, however, somewhat different from that of the drag. The green-sand core shown at *g* in Fig. 30 (*b*) is fastened to the cope by arbors and bolts. When facing sand to a depth of from $\frac{1}{2}$ to $\frac{3}{4}$ inch has been riddled into the pattern board, the arbor shown at *k* in Fig. 31 is put in place as illustrated at *k* in Fig. 30. The arbor and the bolts that hold it up when the cope is lifted off the pattern board are clay-washed before they are put in so that the sand will adhere to them. Sand is then filled in a little higher than the top of the

arbor, facing sand being kept next to the pattern. The small arbor *l* is then put in place after having been clay-washed. It



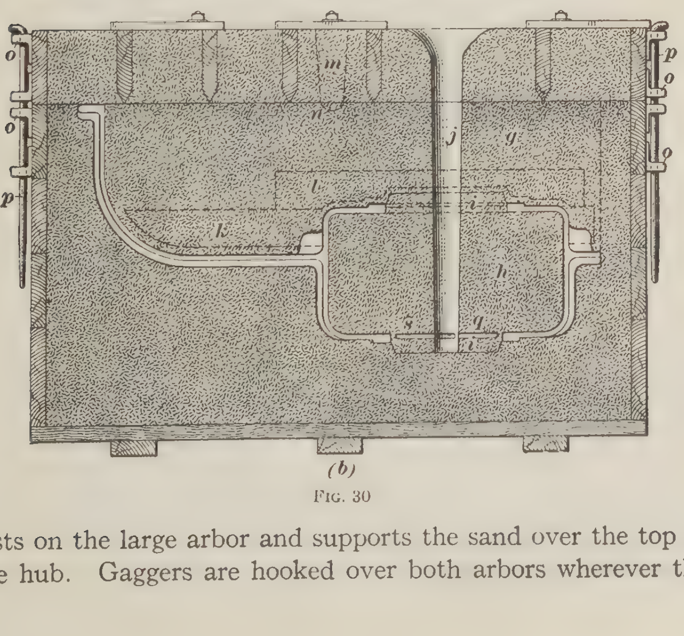


Fig. 30

rests on the large arbor and supports the sand over the top of the hub. Gaggers are hooked over both arbors wherever the

sand needs further support between the bars. The small arbor is shaped so that sufficient room is left for the sprue pin, which is located by means of a dowel-pin in the correct position on the end of the core print, so that the hole in the cope will meet the one in the dry-sand core. The recess in the pattern plate is then filled with sand and rammed, the cope is put on, and the riser pin *m* is put in place where it will later be joined to the mold of the gate *n*. The cope is then filled and rammed.

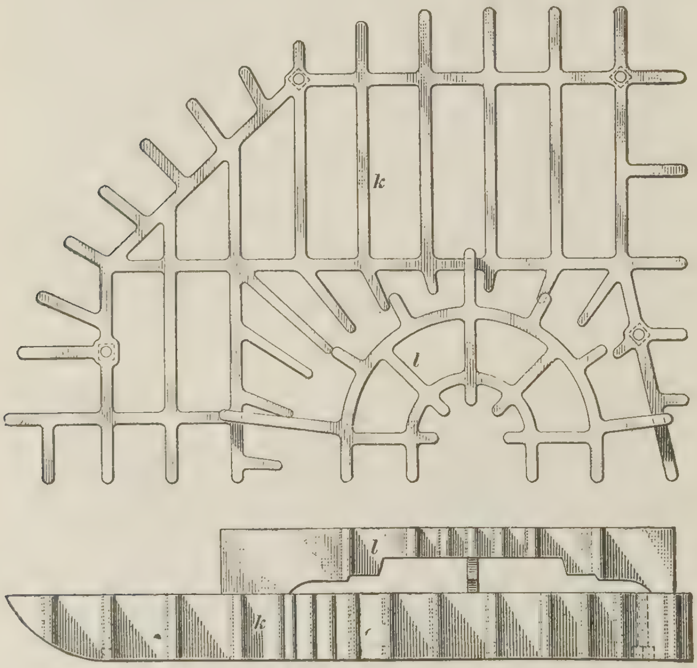


Fig. 51

Before the cope can be lifted off the pattern plate, the arbor bolts must be made fast by means of binders, which are pieces of wood or iron long enough to reach from one cope bar to the next and having holes through them for the arbor bolts. The binders are put on and nuts are then tightened down on the arbor bolts, thus making the arbors fast so that the green-sand core will be lifted with the cope.

46. In order to avoid damaging the green-sand core, it is necessary, when lifting the cope off the pattern board, to provide an accurate guide so that the cope will be lifted perpendicularly. Such a guide is provided by placing two sets of ears as shown at *o*, Fig. 30, with the pinholes in line with each other so that the removable pin *p* will reach through them into the pattern board. The removable pin is made long enough to guide the cope until the sand is well clear of the pattern board. The dry-

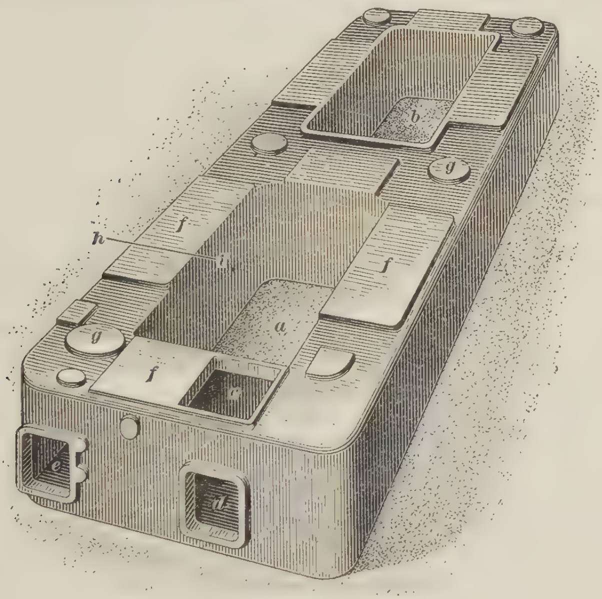


FIG. 32

sand core *h* is set in the drag, but care must be taken to see that the core is accurate in shape and that it leaves the right thickness of metal on all sides and that the gates *q*, *s*, etc. are not obstructed. The cope may then be closed on the drag and guided into place by the removable pins used when lifting the cope off the pattern board.

47. Swept Molds.—The expense for large patterns may sometimes be largely avoided by using *sweeps* and *guide frames*. Sweeps are wooden forms made to match the outline of some

part of the casting. A casting that lends itself well to this form of molding is shown in Fig. 32. This casting is a large bed or base 8 feet wide by 20 feet long and 30 inches deep, with metal 1 inch thick, except where unusual strength is required, when the thickness is somewhat increased. There are two openings *a* and *b* through the frame. The under side of the frame is open except at the end, where the openings *c*, *d*, and *e* are placed. These openings lead into an oil well formed inside the base. There are a number of pads *f* on which parts of the machine are to rest and bosses *g* through which holes are to be made for bolts. The mold is made in a pit; it is formed by three frames that conform to the outline of the base, as will be explained, and a number of sweeps. It is therefore a swept mold that is made without a pattern such as has been used heretofore.

48. The first thing to do in preparation for the making of the mold is to dig a pit somewhat longer and wider than the mold is to be and deep enough to leave room for a cinder bed below the mold. In this case the pit may be 22 feet long, 10 feet wide, and 40 inches deep. The bottom of the pit is rammed hard, a bed of cinders 4 inches thick is put into the pit and butt rammed to make it uniformly hard, and outlet pipes extending above the floor are inserted at several places. A bed of uniform hardness is necessary, as soft places would be compressed by the weight of the metal when it is poured into the mold and cause the formation of considerable swells or humps on the casting. The pit is now filled with molding sand to within 5 inches of the top. Layers of sand about 6 inches thick are put in the pit and rammed, the first two courses being rammed extra hard, because they must support the weight of the casting when the mold is poured.

Straightedges are then set and leveled in much the same way as when making an open-sand mold for a flat plate. In this case, however, three straightedges are set crosswise in the bed, one being placed at each end and one in the middle of the bed. The middle straightedge should be set and leveled first and then the end ones should be leveled from it in the same

way as when molding a flat plate in open sand. The bed is then completed by filling and ramming hard and striking off to the level of the straightedges, which are then removed, and the trenches filled and leveled with the rest of the bed.

49. The mold is marked out on the sand bed by frames or templets that are laid on it. These frames are shown in Figs. 33

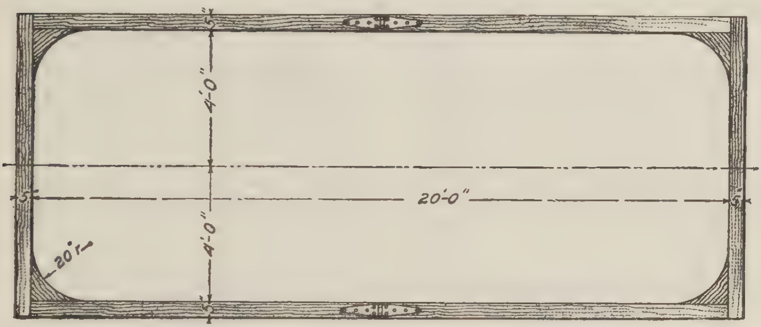


FIG. 33

and 34. The inside edge of the large frame is the exact size and shape of the outside of the casting and the outlines of the openings *a* and *b*, Fig. 32, are obtained from smaller frames like the one shown in Fig. 34. For greater convenience in handling, frames that are more than 12 feet long are jointed and the two parts are hinged together, the hinge side of the frame being laid next to the sand so that the smooth side is up. The frame shown in Fig. 33 is, on account of its large size, likely to be somewhat strained by handling and it must therefore be lined and squared when being placed on the sand bed. One side is first straightened by a line stretched lengthwise of the frame and the frame is then squared by measuring diagonally across it, first one way and then the other, until the two measurements are found to be equal. The other long side is then made parallel with the first one by measuring crosswise of the frame at the ends and in the middle. When the large frame is squared and trued, it is

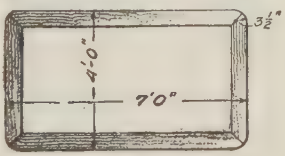


FIG. 34

fastened by stakes driven outside the frame at each corner and near the joint on either side. These stakes are $1\frac{1}{4}$ inches square and 5 inches long and they are driven in until only $\frac{1}{2}$ inch remains above the sand bed.

50. The inside frames are then set by means of gauge sticks, as shown at *a* in Fig. 35. One of the gauge sticks is

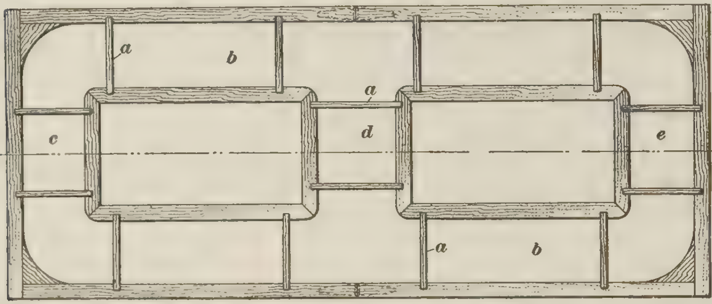


Fig. 35

shown in Fig. 36 and the others are like it, the length *a b* in each being made equal to the width of the trench at whatever point the gauge is to be used. The inside frames are then set by driving a stake inside of each corner. When all of the frames are set, lines are drawn in the sand inside the large frame and outside each of the small ones, thus outlining on the sand bed the mold that is to be made.

After the mold is marked out, the frames are taken up in order that the bed may be vented, which is done with a $\frac{3}{8}$-inch rod long enough to reach the cinder bed. A row of vent holes 3 or 4 inches apart is made about 2 inches outside the mark for the outside of the mold and about the same distance inside the marks that were made around the smaller frames. The top ends of the vent holes are then stopped up with the end of the finger and the surface made smooth with riddled sand struck off with a straight stick. The frames are then replaced in the

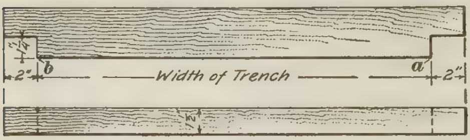


Fig. 36

same position as when previously set and weighted down so that the top surface will be true to the bed.

51. The bed is now ready for the making of the mold. The casting is to be made upside down, the hollow interior is to be formed by a green-sand core, which is to be molded in a trench that is afterwards swept out larger so as to mold the outside of

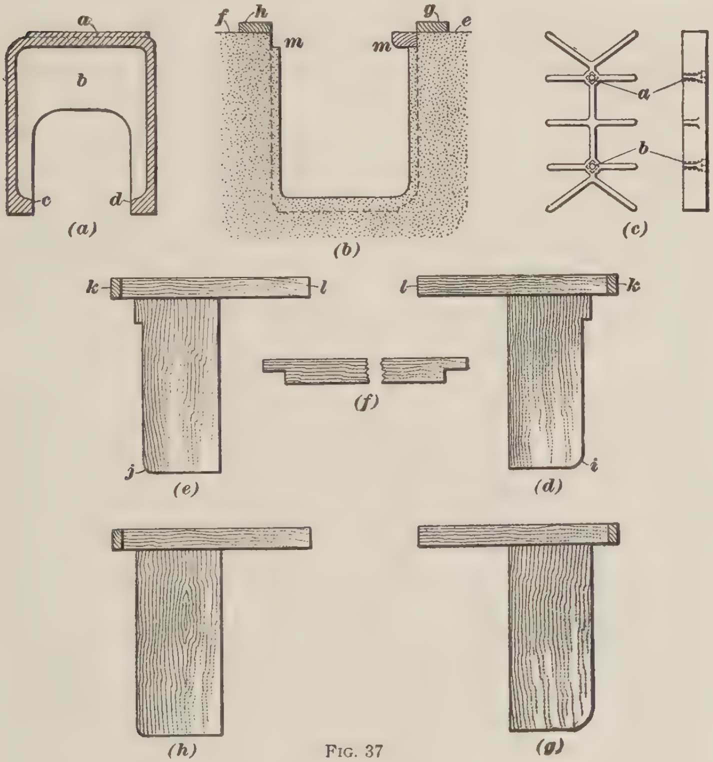


FIG. 37

the casting. The trench is dug in the space *b*, *c*, *d*, Fig. 35, between the frames and it is swept to the exact size and shape of the core.

In order to understand more clearly the details of the mold that is to be made, suppose that the casting shown in Fig. 32 were cut at *h i*. The section thus obtained would appear as

shown in Fig. 37 (*a*), in which the pad *a* is for the support of some kind of a machine, and ribs, such as the one shown at *b*, strengthen and stiffen the frame. Inside flanges *c* and *d* give the frame a better bearing on the foundation. The trench is shown in (*b*) swept out for the core of the section shown in (*a*). The surface of the sand bed is at *e f*, the outside frame at *g*, and the inside frame at *h*. After the core has been molded in the trench and lifted out, the trench is swept out to the size and shape of the outside of the casting, as shown by the dotted lines. The flanges are made by bedding patterns in as will be explained.

52. Two sweeps are required to form the mold for the core; one is used on the outside of the trench and the other on the inside. These sweeps are alike except for the corners *i* and *j*, as shown in Fig. 37 (*d*) and (*e*). The bars *k l* must be long enough to reach across the trench and rest on the two frames, and crosspieces are put on the bars at *k* to keep the sweeps perpendicular in the trench. When the trench has been swept to the size shown by the solid lines in view (*b*) for molding the core, the sides and bottom are covered with paper, which is held in place by small nails, and the patterns for the ribs and inside bosses are put in place and fastened by nails or iron rods about 4 inches long stuck into the sand on each side. These nails may be drawn as fast as the sand is filled and rammed up to them, or they may be left and the scars made in the core by them patched by hand.

The sand would not be strong enough to lift such a core as this one and arbors or lifting irons that are bolted to the cope are therefore used. One of these arbors is shown in Fig. 37 (*c*). There are two holes *a* and *b* for the cope bolts and square recesses receive the heads of these bolts and keep them from turning. The bolts fasten the cores to the cope. Both the bolts and arbors are clay-washed and put in the trench after about $\frac{1}{2}$ inch of facing sand has been put in the bottom. Small gaggers are next hooked over the ribs on the arbors so as to thoroughly support the sand of the core. The trench is then rammed full of sand up to the shoulders *m* in (*b*). The

flange patterns are put in and facing sand is rammed about 2 inches thick even with the top of the pattern on the inside.

53. A trench is then dug for a cinder center in the core. The trench is tramped and all parts of the core are vented to it, especial care being taken to vent under the flanges. Medium fine cinders are rammed solid in the trench and riddled heap sand is tramped and butt rammed between the flanges. No trench was dug at *e*, Fig. 35, because the oil well is to be made in that end of the frame. The sand is surfaced at this point with the strike bar shown in Fig. 37 (*f*) and the frames are then removed. The joint is made level with the top of the flange patterns, which may be used as guides. Parting sand is then put on the joint excepting on the core between the flanges.

The cope, which is in this case made in three parts for convenience in handling, is put in place, with the core bolts reaching through the cope between bars. The cope is about 10 inches thick and extends from 10 to 12 inches over the mold on all sides. Sprue pins are set over the core at intervals of about 3 feet to let the gas out of the core and riser pins are put both outside the mold and inside the central cores. Four risers, each about 4 inches in diameter, are placed along each side of the mold and two are placed at diagonal corners of each of the central cores. Three sprues to pour the casting through should be put in the center of each of the central cores and the cope may be filled with sand, rammed, and then vented over the flange patterns. The core bolts are now secured by putting plates, as many washers as may be found necessary, and a nut on each one. These plates must be long enough to reach from one cope bar to the next and thick enough to carry the weight of the suspended cores. The cope is then staked, lifted off, and put on supports that are high enough to permit drawing the flange patterns and patching the cores from beneath.

54. When the copes with the cores attached have been lifted off, the frames are put back, the mold is swept out to the size of the casting, and pouring gates are set. The iron is taken from the bottom of the sprues along runners to down gates that

lead to a point near the bottom of the mold, where it is admitted to the mold either through a core gate or a draw-in gate. The core gate, which is a dry-sand core, is used when the gate enters the mold some distance from the bottom and the draw-in gate is used when the gate is placed at the bottom of the mold. In order to finish the mold and set the gates, about 2 inches of sand are cut from the sides and bottom of the trench and recesses are cut when the down gates are to be set. The down gates

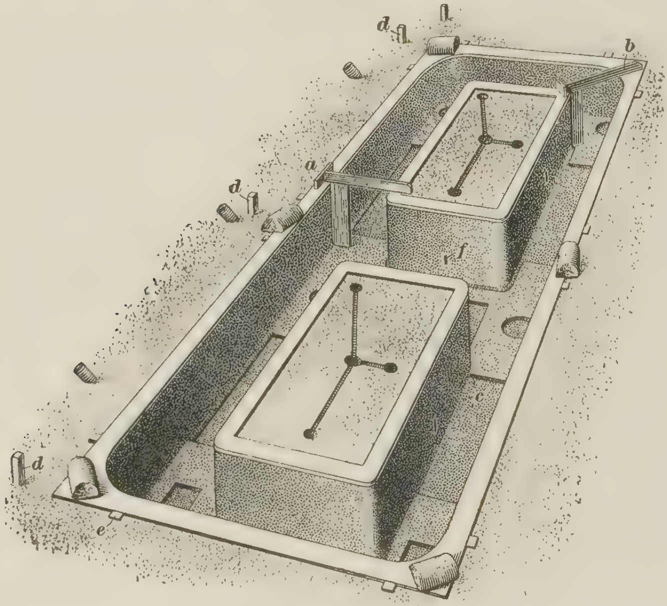


FIG. 38

are set about 4 inches back from the face of the mold, sand is rammed around them, and facing sand to a thickness of $1\frac{1}{4}$ or $1\frac{1}{2}$ inches is filled in on the sides and bottom of the trench. The trench is then swept to the correct surface by using the sweeps shown in Fig. 37 (*g*) and (*h*), which are 1 inch longer than the core sweeps.

Fig. 38 shows the trench while it is being swept out to the mold size. The outside sweep is shown at *a* and the inside sweep at *b*. After the trench has been swept to the size of the

mold, pieces called *pad sweeps*, are fastened to the main sweeps. The pad sweep projects beyond the main sweep and is used to form depressions in the bottom of the mold for the various pads, one of which is shown at *c*. The stakes shown at *d* mark the location of the cope when it is replaced and the stake at *e* holds the outside frame in place.

55. There are from three to six pouring gates in each of the center cores; these are placed when possible opposite ribs through which metal can flow freely to the outside of the casting. One of the gates is shown at *f*.

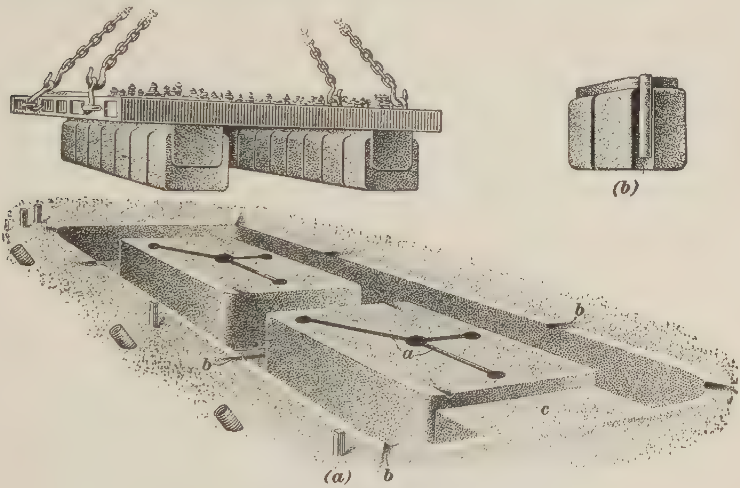


FIG. 39

The mold is shown ready to close in Fig. 39, in which one of the sections of the cope is about to be lowered into place. The niches, such as the one shown at *b*, are gates to the risers. Fig. 39 (*b*) shows a part of one of the cores in which a boss for a foundation bolt has been molded. The hollow interior of the oil well is molded by the dry-sand core shown in place at *c*. This core is supported on flat-head chaplets, and there are stem chaplets that reach through the cope, and are wedged to hold the core down. The openings *a* and *e* in Fig. 32 connect with the oil well and provide a means of venting the core when pouring the casting.

CORE MAKING

SAND CORES FOR CASTINGS

CLASSES AND RELATIVE ADVANTAGES

1. Kinds of Cores.—A **core,** as treated in this Section, is a body of sand used in a mold usually for the purpose of forming an opening in a casting. Cores are known as *green-*

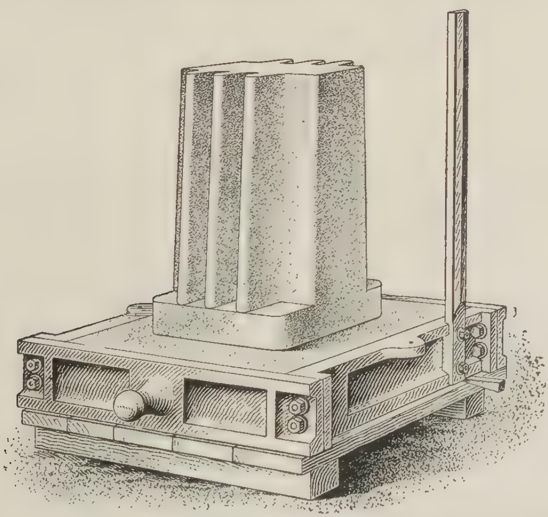


FIG. 1

sand cores and *dry-sand cores*, depending on the materials used and the method followed in making them. **Green-sand cores** are made of sand in the damp state; this sand is rammed into

a core box or swept up to the proper shape, similar to the making of green-sand molds. **Dry-sand cores** are made of damp-sand mixtures and are baked until they are dry. The mixtures are made so that the cores will be hard and strong, also porous so that gases can escape through them. These cores are made in boxes or swept up by hand; they are also made with machines.

2. Comparison of Green-Sand and Dry-Sand Cores. Dry-sand cores are necessary when the cores have intricate forms and when the location of the cores is such that green-sand cores would not stand handling. Generally, the mixtures required for making dry-sand cores are more expensive than the materials needed for green-sand cores. Large green-sand cores, such as, for example, the 3-foot core shown in Fig. 1, are made economically on jolt-ramming machines similar to those used in green-sand molding.

GREEN-SAND CORES

SWEEPING GREEN-SAND CORES

3. Green-Sand Cores for Pipes.—A swept-up green-sand core might be used in casting the pipe shown in Fig. 2. Pipes from 6 inches to 4 feet in diameter and from 1 to 8 feet in length are made with swept-up green-sand cores. This way of casting a pipe furnishes a good example of setting green-sand cores. One way of making cores for this kind of work is shown in Figs. 3 and 4. A section through the mold is illustrated in Fig. 3. The core is swept up on a cast-iron core barrel *g* that has prickers *h* on the outer surface. These are spaced from 2 to 3 inches apart and help to hold the sand on the barrel when the core is being made.

4. Sweeping Up of Core.—To form the core, the core barrel is set on horses *a*, Fig. 4, and is coated with a good thick clay wash or with thin flour paste, or else it is wet with

water, so that the sand will stick to it. The sweep board *b* is set so that its straight beveled edge is at the proper distance from the core barrel to give the required diameter of core. It may be brought up against the removable flanges *c* of the core barrel, if these are of the same diameter as the required core; but it is better to use stop-pins, as shown at *d*, because the rubbing of the flanges *c* against the board *b* will wear the board and cause it to vibrate and may cause the sand to drop while the core is being made. The core barrel is turned slowly by means of the crank, and the sand is packed on by hand. The sweep board scrapes off the high places and brings the core to a uniform diameter throughout. After the core has been swept up nearly to the required size and before the last revolution is made, some well-tempered sand is riddled on through a $\frac{1}{8}$-inch riddle to make the core as smooth as possible.

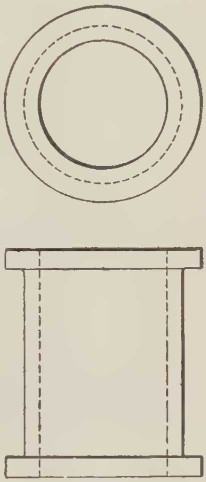


FIG. 2

5. **Finishing Swept Cores.**—For thin pipes, slicking the surface of the core should be avoided whenever possible. The metal will then lie more readily against the core, allow

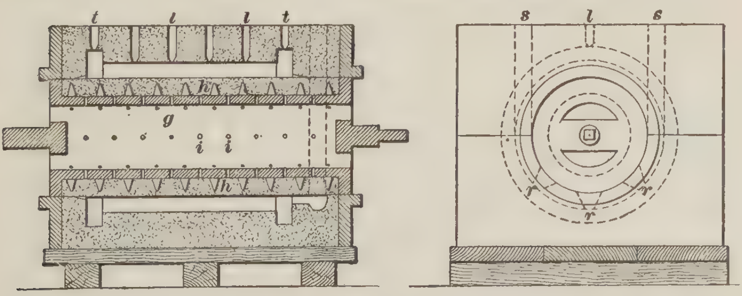


FIG. 3

the mold to be filled better, and make the casting free from cold shuts. When pipes are over $\frac{3}{4}$ inch thick, the cores

may be slicked to advantage and may even have blacking rubbed on the top and lower halves, thus making the inside of the pipe peel smoothly. Should pipes be poured from top gates *s*, as shown in Fig. 3, it is well to rub a good coating of heavy blacking or plumbago on the surface directly under the gates where the iron will strike the core.

6. Cast-Iron Core Barrels.—Two designs of cast-iron core barrels are in common use. In one the barrel is cast with prickers, as shown in Fig. 3; in the other design, ribs are run the whole length of the barrel. It is desirable to avoid

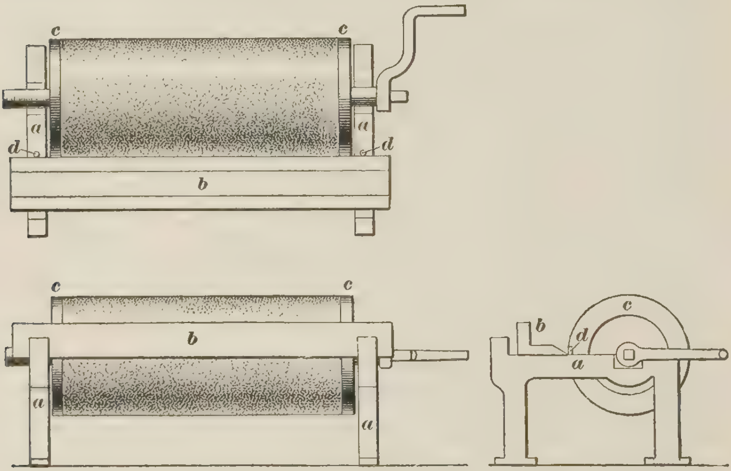


FIG. 4

the use of ribs and to give prickers the preference whenever possible, as the latter hold the sand much better. The ribs separate the sand into sections, whereas the prickers keep it more nearly in one body. In making core barrels, the space allowed for sand usually varies from $\frac{3}{8}$ to 1 inch. Generally, the larger the barrel, the greater should be the space allowed.

7. The greater the diameter of the core barrel, the less is the danger of its springing or sagging. A cast-iron core barrel should be perforated with vent holes, as shown at *i*, Fig. 3, which should be from $\frac{3}{8}$ to $\frac{1}{2}$ inch in diameter and

about 4 inches apart. These holes should be kept free from sand and clay wash, so that they may readily carry away the gases generated when the mold is poured. If only one or two castings are wanted, wooden core barrels may be used. These have nails driven closely all over the outer surfaces, to hold the sand. However, the wooden core barrel does not allow the mold to be vented properly.

MAKING GREEN-SAND CORES IN BOXES

8. Round Cores.—For a standard line of work requiring round cores, it is advisable to use core barrels like that shown in Fig. 3, but if orders are received for only one or two castings, it would be an unnecessary expense to provide such core barrels. In the latter case, it would be wise to make the cores by the method shown in Fig. 5. The core arbor *l* is made in one piece with the ends *m* and *n*, which are circular and fit snugly in the core box. The end *m* is a little smaller than the inside of the pipe or cylinder, in order to allow the arbor to slide easily out of the casting when cleaning it. Between the ends *m* and *n* are the cross-bars *1*, *2*, *3*, *4*, and *5*. They come only half way up in the core, which in ramming is made solid up to the line *o*. When the core is rammed this far, it is vented down to the bottom, with cinders or fine coke placed over the vents, to connect with vent rods run through the holes *p* in the end of the arbor. Sand is next shoveled on and the first course is lightly tamped with the butt of the rammer. The sand required to finish the top half of the core is packed down firmly with the hand after the butting; the top

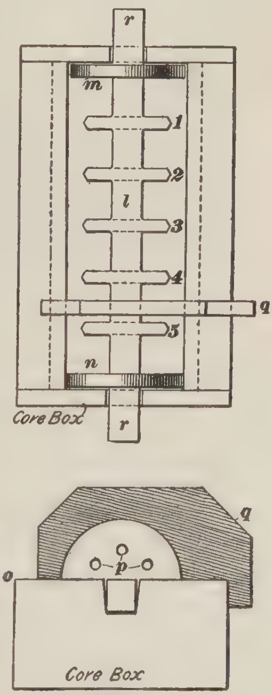


FIG. 5

half is then closely vented down to the cinders. The vent holes having been stopped with the palm of the hand, a *strike*, or sweep, *q* is pulled gently from one end of the core to the other to give form to the top half. The first *striking off* of the core will leave it a little rough. This roughness is smoothed by sifting on sand and packing it lightly with the hand, after which the strike *q* is worked from end to end. If the core is for thick castings, the top is slicked and, if necessary, blackened.

9. Finishing of Core.—After the top of the core is finished, the whole is lifted out of the core box, the lifting chain being attached to the ends of the arbor, as shown at *r*, Fig. 5. The bottom of the core is then finished by patching where necessary and smoothing it over. In the case of large

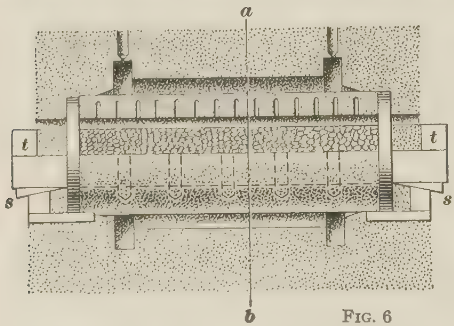
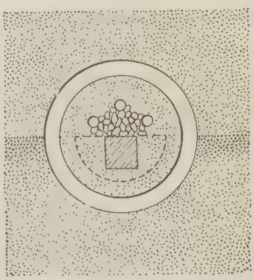


FIG. 6



Section Through *a b*

cores, blocks with square notches cut in them are nailed on top of the trestles. The ends of the arbor fit in the square notches and the core rests on the trestles while it is being finished.

10. Setting of Core.—A section of the mold, with the core in half section, is shown in Fig. 6. In setting such a core in a large mold, plates and blocking *s* are often provided, as there is a liability that such a heavy core, when left to depend wholly on the sand for a bearing, will crush the sand, which will cause it to drop into the mold at the ends near the bearings of the prints. By means of the blocks and plates *s*, solid bearings for the core are provided; wedges can be inserted to bring the core to its proper height.

11. The objection to making cores as shown in Fig. 5 is that it requires more sand, time, and labor than is needed with the method previously described. For pipes or cylinders over 24 inches in diameter, this method is necessary with the general run of sand. When pipes larger than 24 inches in diameter are cast in a horizontal position, there is some danger of the pressure raising the upper half of the core off the barrel when the mold is being poured.

12. Core Arbors and Square Cores.—In making square columns, green-sand cores can often be used to advantage. Fig. 7 shows one style of core arbor used for such work. In making such an arbor, a stout rectangular bar *n* is cast and then loose cross-plates *o* are fastened to it by wedges *p*. Wood is used for wedges for the reason that it will char and leave

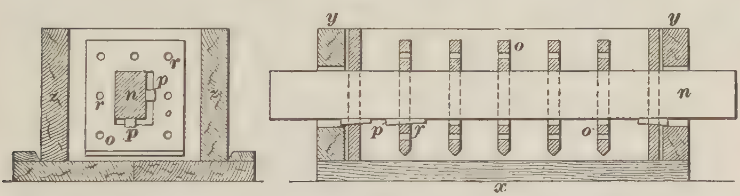


FIG. 7

the cross-plates free, thus permitting the core to be readily removed from the casting. If there are a number of such castings to be made and they are not too long, the bars can be cast in one piece by providing prints on the cross-plates to cast vent holes *r* to admit vent rods. The core boxes for large square cores are generally made of wood. They have loose sides *z*, loose ends *y*, and a loose bottom *x*. The top of the core is struck off with a strike. These boxes are held together at their ends with screws or clamps, and, if they are long, clamps or stays are used at the center to keep them from springing.

13. Bearings for Core Barrels.—In casting the larger sizes of pipes and cylinders, it is essential that the core barrels should have good bearings. Pipes and cylinders from 3 to 6 inches in diameter may be cast by having sand-print bearings

only, but above these sizes the ends of the arbors should be turned true, so that they may exactly fit the flask ends or fill the prints. By having such rigid bearings, the core will be kept in place. If the ends of an arbor and a flask cannot be made to fit each other closely, blocking and wedges as shown at *s*, Fig. 6, may be necessary; and the blocking shown at *t* can be carried up under cross-bars or weights, which can be wedged to prevent the cores from rising.

14. Ramming Cores and Gating Molds.—In making green-sand cores, care and judgment must be exercised to have the lower parts no harder than is necessary to hold the sand together well while casting. It is advisable not to ram the core closer than within 1 inch of the core box. The core will thus be kept firm, yet at the same time soft enough to eliminate any boiling of the iron due to hard spots. The upper part of the core should, as a rule, be rammed so as to be firm but open, so that the iron may have close contact with it. If pipes or cylinders are poured with the gates, as shown at *l*, Fig. 3, arranged for the metal to drop from the top, the sand must be of a stronger character and should be rammed a little harder than would be necessary if they were poured at the bottom and the metal allowed to flow through the inlet gates *r*. These gates are connected with the upright gates *s* by a gate under the bottom print 3 or 4 inches back from the edge of the flange. In casting pipes it is wise to have risers or feeders *t* on the tops of the flanges, and when pouring the casting to cover them with balls of clay, as it is always better to have the molds air-tight when pipes are cast flat.

15. Use of Chaplets With Long Cores.—In some cases it is practicable to use chaplets on the bottom and top of green-sand cores, thus permitting the use of slim core barrels and consequently the casting of long pipes; they may also be used to aid stout core barrels should it be desirable to do so. For this purpose, a knob is generally cast on the under side of a core barrel and is made to come flush with the bottom face of the core. This knob is intended to come directly over a chaplet and so cause a connection of iron with iron

to support the core. For chapleting the cope, a hole may be cut in the core down to the core barrel and loose pieces of iron or nuts may be inserted and made flush with the top face of the core. The cope chaplets may be set on these loose pieces and when shaking out the core barrel, the loose pieces will work loose and permit the release of the barrel.

DRY-SAND CORES

SMALL ROUND CORES

16. Core Boxes.—The simplest forms of dry-sand cores are those of round or square section. They are made in boxes, as shown in Fig. 8. The box is made in halves that can be taken apart easily and quickly, to allow the core to be removed after it has been rammed to shape in the box.

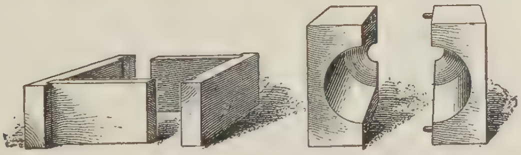


FIG. 8

The halves of the box are held in their correct relative positions by grooves or by dowel-pins. Core boxes are made of wood, iron, and brass.

17. Cores With Central Vents.—Square cores are more easily made than round cores. The method of making plain round cores will therefore be described, as it involves some of the principles used in making intricate cores. In Fig. 9 (*a*), a core box is shown clamped together and the core is being rammed. After about 2 inches of the core has been rammed, the box is turned end for end and a vent wire is pushed in through the center of the core, as shown in (*b*). The box is then turned back to the first position and the core is rammed up to its end, care being taken to keep the vent rod *a* in the center, as shown in (*c*).

Fig. 9

18. Some core makers, in trying to ram up a core like that in Fig. 9, merely ram it up to the end without changing the position of the box and after the core is rammed shove a vent wire from the top to the bottom. This process may give a vent running to the side of the core, as do the vents shown at *e*, Fig. 10, instead of its being central, as the vent shown at *f*. Cores vented as at *e* often cause castings to be lost. When small cores are used in considerable quantities, several cores of the proper length are usually made in iron core boxes at one time. The cores are rammed by simply pounding the core box on the work bench, the jarring being sufficient to pack the sand to the proper density. Machines are also used for this class of core making.

19. Setting Vent Wire Central.—One method of insuring that the vent wire will be

central in the core is shown in Fig. 11 (*a*) and (*b*). Three cleats *a* are fastened to the core bench in such a way that when the core box is set inside them it will fit snugly. A hole *b* is made in the bench in such a position that when the core box is put in the cleats it will be central with the hole *c*. The vent wire *d* is then dropped down the hole *c* and into the hole *b*, thus insuring that the vent will be in the center of the core.

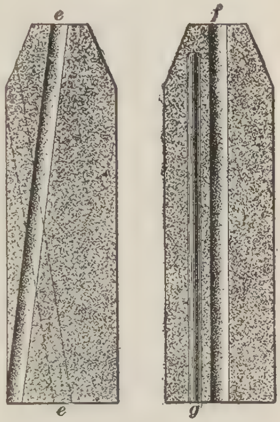
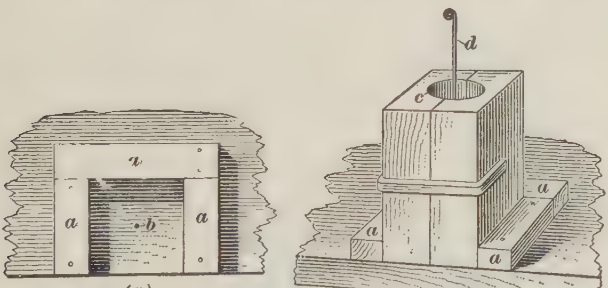


Fig. 10

20. Sizes of Rods for Ramming Cores.—The size of the rod used to ram the sand in a core, as shown at *b*, Fig. 9 (*c*), is important. It is not uncommon to see a molder using such a large rod that it nearly fills the box. It will be found that when such large rods are used, the cores when dried will often fall to pieces, because every ramming forms a smooth surface, and this prevents successive layers of sand from adhering; whereas, if a small rod were used, the adhesion between the layers would be strong enough to stand rough handling. For ramming a 1-inch core, a $\frac{1}{4}$- to $\frac{3}{8}$-inch rod is large enough. For a $1\frac{1}{4}$- to $1\frac{1}{2}$-inch core, a $\frac{3}{8}$- to $\frac{1}{2}$-inch rod will do the work. This proportion between core and rod should be used in ramming cores so as to avoid the formation of joints and to have the



(*a*) Fig. 11 (*b*)

layers thoroughly united. Where cores of the smaller sizes are to be placed horizontally in molds, or are to stand rough usage when placed in a vertical position, rods are placed in them in the manner shown at *g*, Fig. 10. As a rule, a greater number of small cores are used without rods than with them.


(a)
(b)
(c)
Fig. 12

21. Rodless Round Cores. In making rodless round cores, care must be taken to prevent their breaking when placing them on plates for drying. A smooth, straight plate, as shown in Fig. 12, is necessary for this purpose. In placing the core on the plate, the operator after having rapped the core box carefully turns over the half of the core box containing the core, as shown in (*a*). Then with the core on a level with the plate, the box is inclined until the core will roll out on the plate. The core box is then lifted off, as shown in (*b*), and finally, using the edge of the core box, the core is carefully rolled toward the edge of the plate, as in (*c*). If one end of the core is tapering, it should have a little sand placed under it, as shown at *m*, Fig. 13, to prevent the core from sagging out of shape. Sometimes the core plate is made with grooves that just fit the core. A good support is thus given to the core and the under side is prevented from becoming flat during baking.

22. Making Cores in Formers.—In making cores that cannot rest on straight plates, or that would sag out of shape if made in one piece, it is often desirable to make them in halves, as shown at *n*, Fig. 14. These parts, when pasted together, would appear as at *o*. Many cores are so irregular in form that they can best be made in two or more parts and afterwards fastened together.

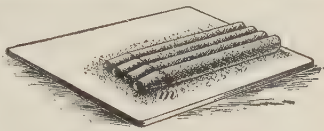


FIG. 13

The plain, round core *q*, Fig. 15, is in one piece. To dry such a core so that it will not sag out of shape, a former, as shown at *p*, made of cast iron, as light as practicable, is placed over the core *q*, and the whole is rolled over, leaving the core ready for the oven. In many cases, instead of turning the core into a former, the former constitutes half of the core box and is so arranged that, when the core is rammed, but one-half of the box, as the part *a*, requires removing. This plan saves labor, and, besides it gives cores free of joints, which are very desirable. If there is any chance that the sand may stick to the iron formers, oil can be rubbed lightly over their surfaces, and in some cases, parting sand can be sprinkled over the oiled surface. The latter plan is generally followed when making large cores in formers.

FIG. 14

23. Drying of Cores.—When a plate has been filled with cores, it should be put into the oven as soon as convenient, because cores exposed to the air dry so slowly as to become brittle and weak. Cores are dried in ovens that are so arranged as to maintain a high temperature and are provided with means for removing the vapor by a circulation of

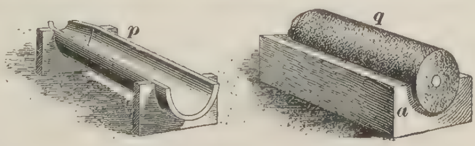


FIG. 15

dry air. A high, even temperature must be maintained, because cores have to be *baked*. Ovens for drying small cores should be made as convenient as possible and arranged so that the heat can be regulated in such a way as not to burn the cores.

TREATMENT OF CORES

24. Pasting Cores.—By **pasting** is meant the placing of some material on the surfaces of the halves of a core to cause them to stick when put together, so that they can be handled and placed in the mold without separating. The material generally used for pasting is wheat flour wet with water or molasses water to form a smooth, uniform paste. White wheat flour forms the most sticky paste; but for cores that are not to be handled roughly, a paste made from graham or buckwheat flour, sometimes called *meal*, is often more desirable. It can be handled more quickly and put on more evenly on account of its not being so sticky as a white wheat flour paste. It is well to apply the paste while the cores are hot, as they stick better than when pasted cold.

25. In pasting joints that have vents, care must be taken to keep the vents free from paste, as there have been many cases, especially with crooked vents, in which neglect of this precaution has caused bad castings. In some cases, it is well to lay a rod or a string in the vent and to pull it out when the core is joined, thus insuring a clear passage. Cores should never be pasted unless the halves come together closely all over the joint surface. In the case of medium-sized and large cores, it may be necessary to rub the halves together, to grind down the irregularities, before a tight joint can be made; and often, where the cores are very uneven or crooked at their joint, the high places can be filed down before the halves are rubbed together to bring them down to a solid bearing. Care should be taken not to remove too much of the sand at the joint, or the core will not be true to form. After rubbing the joints, the dust created should be brushed off, for if left on it prevents the paste from sticking to the surfaces.

26. Daubing Joints.—After the cores are pasted, the joints must in many cases be filled in so as to make the core as sound as if it were one piece. For this purpose, dry or stiff blacking is mixed with equal parts of fine parting sand and moistened with clay wash, forming *daubing*. After wetting the edge of the joint with a small brush dipped in thin blacking, the daubing is rubbed in and slicked off even with the body of the core. When the daubing has stiffened a little, the line of the joint is rubbed over with thin blacking. In some cases the same sand used for making the core, if sifted fine and wetted to a mud, will answer for daubing. It is chiefly with medium-sized and large cores that daubing mixtures are necessary, as small cores should come together so closely and be so nearly unbroken at the edges of the joints that a little wet blacking, applied with a brush, will close them. It is not necessary to return the core to the oven after daubing unless the edges have been broken badly or the core has been daubed after cooling. A core should always be daubed while still warm, as the heat in the core is then sufficient to dry any patches that may be made.

FIG. 16

27. Blackening Cores.—The cores used in making castings more than $\frac{1}{2}$ inch thick usually need to be blackened so as to peel smoothly. After the cores are taken from the oven and while they are yet warm they are blackened all over. The blacking may be applied with a brush, as shown in Fig. 16, in the case of small round cores that are dried on a plate. In some cases, cores may be dipped in blacking, as shown in Fig. 17. With any method of blackening, the cores should not be hotter than the hand can hold comfortably. If they are too cold, the blacking will wash the sand and make the surface rough, and if they are too hot, the heat will blister the blacking and cause a rough surface that may wash off

when the iron fills the mold. In using a brush or swab to blacken cores, the surface should never be rubbed without having plenty of blacking on the brush, as rubbing a partly moistened brush on a core will give a rough surface, and may, by not thoroughly incorporating the blacking with the body of the core, cause it to peel off when the iron strikes it.

28. The colder the core is, the thicker can the blacking be used on it; but in no case should it be so thick that it will not run smoothly in following the brush or swab and it should not be so thin that the sand can be seen through it. Some-

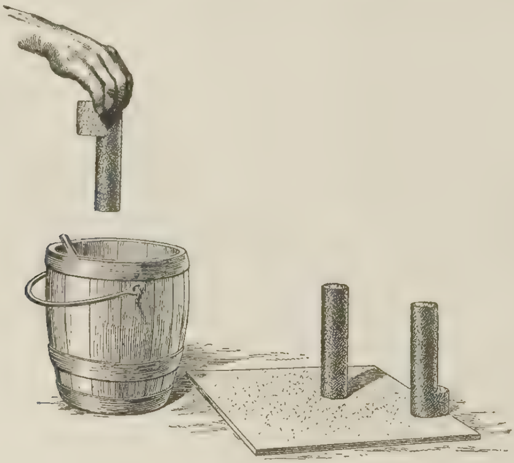


Fig. 17

times cores may be blackened with a brush or a swab before being placed in the oven to dry. Undried cores may be finished with one coat of blacking; but if they are to be used in heavy molds, it is best to apply two coats, the first of thin blacking and the second as thick as will run smoothly. If sufficient thickness is given with one coat, the surface is likely to be torn up at places where the brush or swab may be a little dry. A thicker coat of blacking on undried cores than on dried ones is needed to give a good surface to a casting. Where undried cores are blackened, it may be desirable to slick them in order to obtain a smooth surface. No blacking

is necessary for small cores if they are made of the proper material. In radiator cores and other similar cores that must leave the castings clean, the proper sand mixture with no blacking is all that is necessary. It is much cheaper to make small cores of a proper mixture than to spend the time blackening them.

RODDING AND BARRING CORES

29. Necessity for Rodding and Barring.—Rods or bars are put into cores to strengthen them against handling. Without these bars or rods a core would be left in a brittle condition and would be easily broken by handling or by the pressure of the iron when the mold is being poured. A core weighing more than about 50 pounds would be hard to handle, and as it must be lifted, bars and rods must be placed in the core to stand the lifting pull as well as the jar that naturally accompanies the handling of a body of sand. The bars and rods used for this purpose may be made of wood, wrought iron, or cast iron.

FIG. 18

30. Methods of Rodding and Barring.—Three plans may be followed in placing the strengthening rods in cores. The first is to use single or loose rods; the second, to have the rods welded; and the third, to cast frames or skeletons, usually called *core arbors*. The loose rods are placed singly in cores and

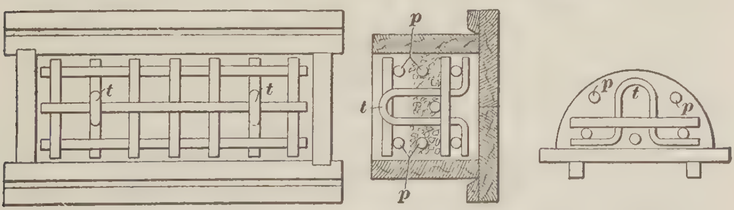


FIG. 19

may be straight, as the rod *g*, Fig. 10, or the rods *a*, Fig. 18; if in greater numbers, they are placed as shown in Fig. 19, the end views of which show rodding for both square and round cores.

In making large cores, provision must be made for lifting them: this is done by means of lifting hooks *t*, as shown in

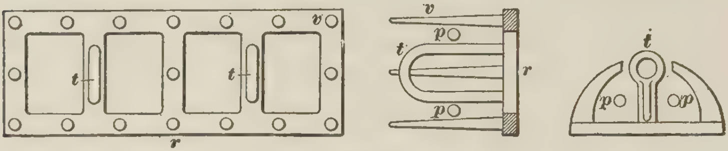


Fig. 20

Figs. 19 and 20. In arranging the rods in the core, Fig. 19, a layer of sand is first put in the bottom of the core box and the lifting hooks *t* are set in place. Over the ends of these hooks are laid the binder rods, extending the full length of the box, and then a series of short bars are placed crosswise on the binder rods. Above these, alternate layers of sand, binder rods, cross-bars, and vent rods *p* are put in. Another plan is shown in Fig. 20, in which a cast-iron frame *r* with prickers *v* is used. Lifting hooks *t* are provided and vent rods *p* are put lengthwise of the core.

31. If a firm is making a standard line of work, it is economical to have the core-room equipment arranged so as to require the least amount of labor in making the cores. For

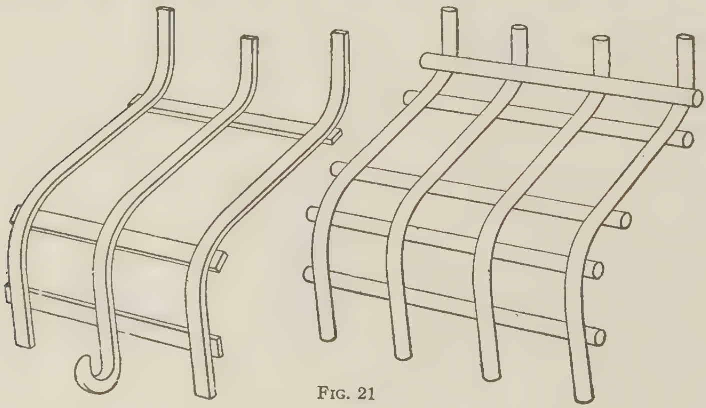


Fig. 21

(*a*) (*b*)

example, if the standard line of work is steam engines, there should be core arbors, Fig. 21, for the cores, Fig. 22, used in

forming the steam ports, as *a* and *b*, Fig. 23. Two forms of core arbors for this purpose are shown in Fig. 21 (*a*) and (*b*). That in (*a*) is a welded core arbor made of bars welded into a single frame and furnished with a lifting hook; that shown in (*b*) is a loose-rod arbor, which is built up as the making of the core progresses.

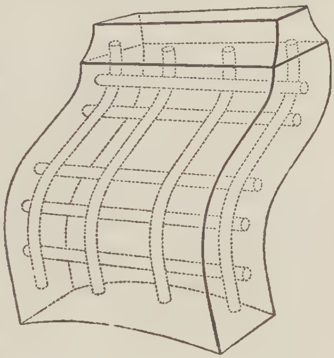


Fig. 22

32. When placing rods and bars in cores, room must be left for vent rods, that are to be withdrawn to form vents to lead the gases from the cores to cinder beds or to the cavities in the cores themselves. The strengthening rods should be bedded in firmly and without springing; otherwise, the cores, especially those of light weight, are liable to crack. Often when long rods are not obtainable, short ones are spliced together and laid as shown in Fig. 18. When this is done, care should be taken to see that the splice is sufficiently strong. One of the two rods shown in full should be a half longer than the other; or another rod should be laid alongside them, as indicated by the dotted lines. The number of rods used should be only enough to support the core in handling and in casting the mold.

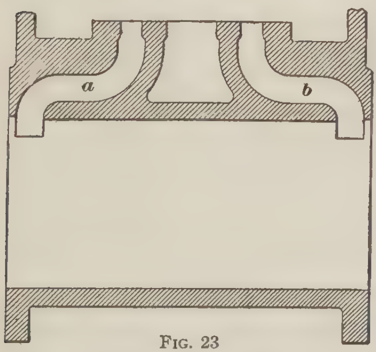


Fig. 23

There are a number of core forms in which the rodding can be dispensed with by making the sand mixture of a certain nature and strength. For example, cores for the center plates of car wheels and also for radiators and similar work are often made without rods.

VENTING OF CORES

33. Methods of Venting Cores.—When the molten metal is poured into the mold and surrounds the core, gases are formed in the body of the core, and these must be led to the outside through passages called vents. Various methods of venting cores are practiced. One way is to fill the center of the core with cinders, which not only saves sand and drying, but also gives a freer vent to the core. Wax strings, rope, and rods are also used for venting purposes. When strings are employed, they are covered with paraffin or beeswax and placed centrally in the core. After the core has been baked, the strings are very easily withdrawn. Rope is sometimes used in the same manner. If rods are used for venting, they are

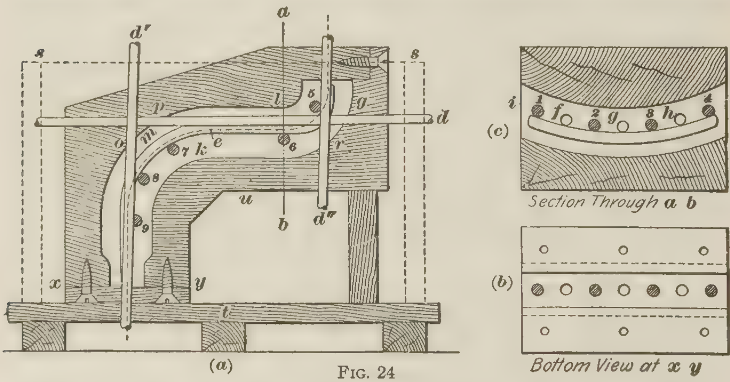


FIG. 24

placed in the core while it is being made, so that they can easily be withdrawn before the core box is removed, and so that the openings thus made connect to form a free passage through which the gases can escape.

34. Venting Crooked Cores.—In Fig. 24 are shown a side view (*a*), an end view (*b*) taken on *x y* in (*a*), and a sectional view (*c*) taken on *a b* in (*a*), of a cylinder-port core box for making the core shown in Fig. 22. To rod this core, the general practice is to use a welded frame, as shown in Fig. 21 (*a*), or loose rods placed together, as shown in (*b*). In making such cores, the core box is screwed or clamped together and set on the bench

with the face *j*, in (*c*), at the bottom. It is then filled with sand to the height of the center *g*, in (*c*). The rods *5*, *6*. *7*, *8*, and *9* are next pressed into place and vent rods *d* are placed at the level of *g*. When vent rods cannot be used, a string shown by the dotted line *e* may be placed in the core box, having one end projecting from it. The partly completed core is now rammed with sand to the height of the rod *2*, and, this rod having been set in, more sand is rammed to the height of the vent hole *f*. The vent rod or string is then placed in position and sand is rammed over it to the height of the rod *1*. After the rod *1* has been located, sand is rammed to the top of the box and the surface *i* is slicked off; then the box is turned on its side, and the unvented and unrodded sand is dug out to near the level of the vent *g*. Sand is next rammed in to make a solid bearing for rod *3*, and the same process in placing vents and rods is continued until the top *j* of the box is reached. When this is slicked off, the vent rods or strings, as the case may be, are pulled out of the core.

35. By noting the position of the cross-rods *5*, *6*, *7*, *8*, and *9* in the core, Fig. 24, it will be seen that a string or a rope having the position shown by the dotted line *e* cannot, in being pulled out of the core, cut away the sand at such points as *k* and *l*, and so bring the vent up against the face of the core box at these points. When vent rods are used in the place of strings, a connection should be made between the vent holes left by the rods d'', d', and *d*. In order to make this connection, grooves may be cut in the core at *m* and *r* and a string covered with paraffin passed through the vent holes and grooves, or recesses, after which the grooves are filled up again with daubing or core sand. The openings at *g*, *r*, *p*, and *o* having been closed, the core is dried either in an oven or by holding hot irons over the places just filled up. After the core is dried, the strings are easily pulled out, because of the melting of the paraffin when heated, leaving the hole larger than the string itself. A continuous vent is thus placed through the core.

36. Drying Crooked Cores.—To handle a core like that in Fig. 22, after the part *l p x* of the core box is removed

and the core finished, a former may be placed on the core, and after turning over, the other half of the box is removed. Another way is to remove the part $l\ p\ x$ of the box, set the other part of the box with the core into a wooden box or frame s, Fig. 24, as shown by the dotted lines, and to fill in the whole space around and above the core to the top level of p with green or common heap sand, rammed carefully so as not to break the core. After the frame has been filled, an iron plate is set on and clamped to the bottom board t, and then the whole box is rolled over. The frame s is then drawn off and the loose sand removed from the top and around the side u of the box, after which the core box is drawn, the core finished, and the whole set in the oven. Many difficult or crooked cores can be made in a similar manner. The majority of steam-engine cylinders are now cast with the cores of the cylinder, steam ports, exhaust ports, and steam chest all made in one piece, or rather in halves, which are pasted together. By making these cores in one piece, there is no danger that the iron will find its way into the vents.

MATERIALS USED IN MAKING CORES

SANDS AND BINDERS

37. Kinds of Sand Used in Making Cores.—The suitability of a core for any special line of work depends largely on the nature of the sand used and the binder mixed with it. Nearly all cores require something to be mixed with the sand to cause them to be firm and hard when dried. Two classes of sand are used in making core mixtures, namely, *sharp sand* and *molding sand*. Small cores, as a rule, require the finest grades of sand and large cores are made from coarse grades. The sands generally used for making small cores consist of fine grades of lake or seashore sands, river and bank sand, and also fire-sand or silica sand. Sometimes these different grades of sharp sand will be mixed in varying proportions with fine grades of molding sand; and, again, there

are some small cores that may be made wholly of molding sand. Bank sands are, as a rule, inferior to the other grades of sharp sand mentioned; still, there are cores in which bank sand, alone or mixed with molding sand, can be used; but bank sand should not be used alone for making a strong core like that shown in Fig. 24. Cores made from silica sand and linseed oil require less ramming and less venting, will dry harder, and will leave the castings freely. Dryers or iron forms, such as that shown in Fig. 15, should be used on most cores of irregular shape made from this mixture, as the cores will not retain their shapes well while green.

38. Binders Used in Core-Sand Mixtures.—The binders chiefly used to give strength to core mixtures are wheat flour, rye flour, resin, glue water, glutrose, and linseed oil. Aside from these, there are on the market several patent core compounds that are used for intricate cores that are difficult to vent. Some founders mix cement with the sand used in cores as a binder. Flour is the most common of all the binders and is mixed with sands, according to their character, in the proportions of from 1 part of flour to 20 parts of sand up to a proportion of 1 part of flour to 8 parts of sand.

39. Flour as a Binder.—Cores made with flour swell and crack more while drying than those made with other binders; it is also the worst binder in use to create stifling gases when the molds are being cast. Some molders in using flour boil it with water in a kettle to make a thin paste, which is mixed again with water to make a thin solution for wetting the sand. If all the water that the sand required could be boiled with the flour, the result would be more satisfactory. Where the cores are required to be especially strong and are difficult to vent, it is much better to mix the sand with the water boiled with the flour. On account of the expansive tendencies of the flour when being dried, care must be taken to dampen the sand only just enough to keep it in solid form. Some molders use rye flour in preference to wheat flour, as it swells and cracks the cores less than does wheat flour.

40. Resin as a Binder.—Some founders use resin altogether in cores, whereas others mix flour and resin together in varying proportions, according to changes in the character of the cores. Resin is largely used for small thin cores, which need not be blackened when so made, thereby saving time and labor. Resin tends to preserve the sharp corners of cores better than most binders. A feature of resin cores is that they cannot be handled hot, because the resin keeps the mixture in a soft state until the dry cores are cold. The use of resin is confined to special sands more than that of flour. Molding and bank sands often work well together in making small cores with resin mixtures, and sometimes small cores may be made by using molding sand alone, provided the mixture is not baked so hard that the gases cannot escape with freedom. Where it is desirable to save labor, venting can often be dispensed with, by mixing the resin with bank sand.

41. Where the cores are especially hard to vent, resin is an excellent binder, as gases caused by resin escape and ignite very freely; another advantage of resin-bound cores is their ability to withstand the dampness of green-sand molds for long periods without absorbing moisture.

If resin comes in lumps, it must be pulverized to a fine powder in an iron mortar, after which it is passed through a fine sieve. A foundry in which resin is used extensively for the making of cores should be provided with a resin grinder. This machine grinds and bolts resin in a way that cannot be accomplished by hand. Besides, finely ground resin will distribute much better in a core sand, and a certain amount will go farther and make better cores than if it were improperly ground.

42. Mixing Binders.—The proportion in which to mix resin with sand depends on the character of the sand and that of the cores to be made. For the general run of new sands, 1 part of resin to 15 parts of sand should make good cores for ordinary castings. If very strong cores are desired, a larger percentage of resin may be used, and such cores can

be further strengthened by wetting with molasses water in place of clear water. A point that should be borne in mind while making strong cores is that the stronger the core, the more difficult it will be for its gas to escape. It may often be advisable to mix a small quantity of flour with the resin. In the case of small cores, it must be remembered that if too much flour is used with the resin, it may be necessary to blacken the cores.

43. It is often very desirable to have the surfaces of cores firm and hard, while the interior is of an open character. A smooth surface on a casting is thus provided and at the same time the gases are given freedom to escape. In such a case, the more open the sand is and the less flour or resin used, the better. To insure firmness on the surface of cores, they may be sprinkled with molasses water before being placed in the oven. When once in the oven, the quicker they are dried, the better, provided that the heat is not sufficient at the start to blister and crack them.

44. Glue Water and Linseed Oil as Binders.—A thin solution of glue with water for use as a binder is applied in the same manner as water for wetting the sand and makes a firm core that is hard when hot as well as when cold. No more of the solution should be used than is sufficient to make the core hard enough to handle. It is an excellent binder in giving freedom for venting, and less gas is probably generated by its use than by that of any other binder.

45. In some cases raw linseed oil is used for making delicate and difficult cores. It makes a very strong core and one that the dampness of green-sand molds cannot readily affect; this quality makes it a good binder for intricate, thin cores that are liable to be confined in a damp mold for several days before casting. Raw linseed oil is sometimes mixed in equal parts with a solution made by adding to benzine all the resin it can dissolve. Cores made with this combination must be baked with a hot fire, and they will vent freely and are proof against dampness even when left standing for a long time in green molds. In a general way, it may be said that

nothing equals linseed oil for making complicated cores, which must vent freely, be strong, and withstand moisture in a mold. Such cores will also leave the casting more easily than those made with any other binder.

No matter how much experience a person may have in founding, he will find that on starting to use any of the binders mentioned he may have to do some experimenting before he can get the best results.

46. Miscellaneous Binders.—There are several features about flour and resin that are not satisfactory, and much experimenting has been done to discover binders better adapted to suit the varying conditions in making cores. A number of founders have tried to replace flour and resin with various compounds prepared and sold by foundry-supply houses. They sometimes mix flour and resin with some compound in varying proportions. Some of these compounds used alone work well in cores designed to crush easily and allow freedom for contraction when the casting is cooling and they are excellent materials for permitting the escape of gases; in fact, they surpass flour in making cores that are difficult to vent.

47. Liquids Used in Wetting Core Sands.—Some core makers use clean water and others make a practice of using a clay wash of varying consistency to strengthen the sands. The more the water is thickened with clay, the greater is its value as a binder, and yet the indiscriminate use of clay is destructive to cores, because a core carrying too much clay in the sand with which it is made is liable to be baked so hard during drying as to prevent the escape of gases during pouring and so prove troublesome while casting. In some cases, when making intricate cores, the sand is wet entirely with glue water, or with molasses water. As a rule, wetting the sand in this way in place of with clear water should lessen the amount of other binding material required in the sand.

CORE-SAND MIXTURES

48. Receipts for mixtures of core sand cannot be given satisfactorily, for the reason that there are few localities that have the same kinds of sand, or that have the same conditions to meet in making cores. In the foregoing discussion, therefore, experience is presented as fully as possible, so that with fair judgment and a few trials, each founder may establish his own receipts for core mixtures. A few receipts that have furnished good results in making small and large cores are given here. Where cores are handled roughly, they should contain more of the binder than where they are handled carefully, and the efficiency of binders can be regulated by the nature of the liquid used to wet the sand.

49. Receipts for Core Mixtures.—Before giving the following receipts, it will be well to state that where cores are dried while on their sides and do not exceed 5 inches in height, the sand mixtures can often be composed largely of sharp sands. Where the cores stand high, or have a poor bearing when drying, this rule does not apply. Where the cores stand high, so that the weight of the top may distort the bottom if it is not well supported, mixtures must contain more or less of molding or loamy sands and must be better rodded.

Receipt No. 1.—Mix 3 parts of sharp sand with 1 part of molding sand. For a binder, use 1 part of flour to 14 parts of sand. Wet with clay wash.

Receipt No. 2.—Mix 2 parts of sharp sand with 1 part of molding sand. For a binder, use 1 part of flour to from 12 to 18 parts of sand. Wet with water or clay wash, as may be desired, in order to obtain strength.

Receipt No. 3.—Mix 3 parts of molding sand with 1 part of sharp sand and for a binder use 1 part of flour or resin to 14 parts of sand; or use 1 part of a binder composed of equal parts of flour and resin to 14 parts of sand. Wet with molasses water.

Receipt No. 4.—Mix 1 part of bank sand with 3 parts of fine lake or crushed silica sand. For a binder, use a mixture

of 1 part of resin to 25 parts of sand, 1 part of flour to 25 parts of sand, and 1 part of some prepared binder compound, such as glutrose, to 30 parts of sand. Wet with clean water.

Receipt No. 5.—Mix 16 parts of No. 2 molding sand, 24 parts of No. 3 molding sand, 20 parts of fire-sand, 54 parts of bank sand, 5 parts of sea coal, 6 parts of flour, and 2 parts of sawdust.

Receipt No. 6.—Mix 16 parts of No. 2 molding sand, 28 parts of No. 3 molding sand, 30 parts of fire-sand, 48 parts of bank sand, 8 parts of sea coal, 6 parts of flour, and 2 parts of sawdust.

Receipt No. 7.—Mix 23 parts of old sand, 9 parts of molding sand, 2 parts of sawdust, and 1 part of core compound. This mixture is for large cores.

Receipt No. 8.—Mix 34 parts of coarse silica sand with 48 parts of fine silica sand and 2 quarts of oil, and wet with molasses water. This mixture is for small and medium-sized cores.

Receipt No. 9.—Mix 48 parts of coarse silica sand with 34 parts of gangway sand and 2 quarts of oil, and wet with molasses water. This mixture is for large cores.

Receipt No. 10.—Mix 48 parts of coarse silica sand, 34 parts of gangway sand, blacking enough to keep the sand from running, 2 quarts of oil, and wet with molasses water. This mixture is also for large cores.

50. Explanation of Core-Sand Receipts.—Where seashore or lake sand is obtainable, mix sand for large cores by receipt No. 1; but cores thus made must be well rammed and rodded, especially if they are to stand very high in the mold. For ordinary cores, receipt No. 2 may be used. Receipt No. 3 makes a good mixture for small cores, and is intended to be wetted with molasses water in the proportion of $\frac{1}{2}$ to 1 pint of molasses to a pail of water. Receipt No. 4 is one that can be used with resin, or flour as a binder, or some prepared binder compound, such as glutrose, and makes excellent cores where they are not so high as to sag with their own weight while green and before being dried. Many molders prefer to reduce slightly the flour in receipts Nos. 1 to 4, and to add 1 part of sea coal to 14 parts of sand, especially for heavy

castings. The sharp sands mentioned in the receipts include seashore, lake, bank, and crushed sands.

51. In receipt No. 4, the resin and flour may be left out, if desired; but if the binder compound only is used, the quantity given must be doubled. Some founders are now making mixtures composed wholly of compound and sharp sand for cores that can stand up without requiring strong sands in the green form. When nothing but compound is used, receipt No. 4 makes cores that are exceptionally strong when dry, much stronger than any made wholly with flour or resin for a binder. Cores made of this mixture also part very readily from the castings, as the sand when burned becomes loose instead of being baked to a solid, as is the case when flour is used. Receipt No. 5 gives excellent results for medium-sized cores, and No. 6 for large or heavy cores; the molding sand in these two is of the standard Albany grades. The purpose of sawdust in cores is to give good venting. Also, the sawdust mixture makes a core that yields easily as the metal contracts. This avoids pulling the metal apart and spoiling the casting, and at the same time makes a core that can be cleaned out easily.

BLACKING MIXTURES

52. Purposes of Blackening.—In order to peel any part or the whole of a casting formed in a body of dry sand, the sand must be blackened with some infusible substance when the castings exceed from $\frac{1}{4}$ to $\frac{1}{2}$ inch in thickness. If this is not done, the heat of the metal will fuse the sand forming the face of the mold and cause a scale or covering on the surface of the casting. This scale may be from $\frac{1}{4}$ to $\frac{1}{2}$ inch thick on massive castings. In coating the face of dried cores or molds, the greater heat-resisting power the blacking has, the better will the casting peel.

53. Mixing Blackings.—Blackings consist of compounds of plumbago, clay, soapstone, etc. ground very fine. They may be purchased prepared ready for mixing with water or other liquid. To mix blackings, some liquid is necessary to

bring them to a fluid state. The mixture may range in consistency or thickness from the thinnest, which will merely discolor, up to a thick, heavy paint. The liquids used for mixing dry blackings are generally called *washes* and are clear water, clay wash, molasses water, and glue water. By wetting blackings containing clay with clear water, they will serve for castings of medium or light weight. Clear water will rarely answer for heavy castings. Molasses water is generally used; but in some cases clay may be added to form a molasses-clay wash, so as to make the cores stronger. This compound makes a strong blacking; but it should be employed with caution, as too much clay in the blacking will retard venting. When blacking dries on a mold and a close, dense surface is formed, *blacking scabs* may be caused by confining the gases that, in their effort to come to the face of the mold, will blow off the coat of blacking. The characters of dry blackings vary so greatly that a wash that works well with one may not be at all successful with another.

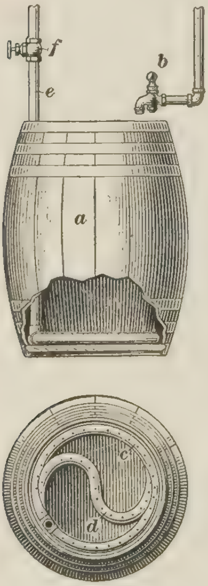


FIG. 25

54. In using the different washes, none demands greater caution than molasses water, for if too much is used it will cause the blackings to crack and flake off from the face of the mold; or a casting may look veined and streaked, after the manner of the seams formed on green-sand castings by using a too strong or badly mixed sea-coal facing. One-half pint of molasses of ordinary strength, diluted with a pail of water, is about as strong as these washes should be made. Salt is also used with some blacking mixtures to prevent flaking and at the same time to act as a first-class binder. A good blacking mixture for general core work is made by mixing about 15 pounds of salt, 110 pounds of blacking, and about 35 pounds of diluted clay wash, and adding enough water to make about 45 gallons of mixture.

55. Blacking Mixer.—A simple and inexpensive blacking mixer is shown in Fig. 25. It consists of a barrel *a*, open at the upper end, into which water may be run from the tap *b*. In the bottom of the barrel are a ring *c* and an **S** *d* made of pipe and perforated on the upper side. Compressed air may be led into these perforated pipes from the air-supply pipe *e*. The desired amount of blacking mixture is first put in the barrel and then the proper quantity of water is run in, after which the air valve *f* is opened. The escape of the air upwards through the contents of the barrel mixes them thoroughly.

56. Details of Mixing.—When mixing blackings, it is best to bring them to a pasty condition before adding a sufficient amount of the wash to reduce them to the right thickness for application to the core or mold. The finer the blacking is ground, the better mixture it will make, and if its quality is good, it will not cause foaming or settle as sediment to the bottom of the mixture; but it will thicken in time. Where the blacking is light and floats on the top of the wash while being mixed, it is of an inferior quality, and should not be used on work demanding a good grade of blacking; again, should a blacking be so heavy as to sink to the bottom in such a manner as to leave the wash separated on the top, it should also be rejected.

57. There is little difficulty in mixing blackings to peel castings of ordinary thickness; but for heavy castings, too much care cannot be exercised. For massive work, it is a good plan to use fully one-third of plumbago mixed with two-thirds of Lehigh coal, coke, or good grades of prepared blacking, and wet the mixture with molasses water containing a small quantity of fireclay. After this has been applied to the core and roughly slicked, the peeling of the casting is aided by going over the blacking with a thin mixture of plumbago that has been wetted with molasses water. In some cases after this solution has been applied, it is well to dust on some plumbago out of a bag or by hand while the face of the core is damp and then to go over the surface with finishing tools This

treatment of cores has caused the sand to peel perfectly from the face of massive castings, such as rolls for steel mills.

58. It is best, when practicable, to have all blackings mixed a day or two before being used, and in taking them from the barrel or tub in which they have been mixed, to pass them through a sieve several times before they are applied to the mold or core. Formerly every founder had his own secret mixture for making blackings, but now manufacturers are making blackings especially adapted to the various thicknesses and characters of castings.

CORE ROOMS

ARRANGEMENT OF CORE ROOMS

59. The core rooms of jobbing foundries are generally much neglected places, being frequently poorly lighted, overcrowded, and with very inferior equipment. In large foundries, and especially in those making specialties, the conditions are usually different. The importance of having good cores is here generally more fully recognized, as it is well known that poor cores are a source of considerable loss in molding. Items that may be small in small shops become large in large shops, and systematic economy and the curtailment of unnecessary expenses are absolutely necessary to financial success. In Fig. 26 is shown the arrangement of a core room. It should, however, be understood that the general arrangement, as well as the details, depends entirely on existing conditions and it is not expected that the equipment of any two rooms will be exactly alike. The core room is either a part of the foundry building or an annex to it. Hence, in a modern plant it has substantial brick walls, as shown at *a*, with a good supply of light through large windows *b* around three sides of the room. The room should have plenty of overhead air space and be equipped with some standard heating and ventilating system. It should have plenty of floor room for all the machines, benches, ovens,

racks, etc., as well as an office for the foreman. Core rooms in foundries making extra-large work are equipped with overhead traveling cranes, jib cranes, or both.

EQUIPMENT OF CORE ROOMS

60. Core Benches.—The core-makers' benches shown at *c*, Fig. 26, are arranged along the walls in front of the windows, so as to have an abundance of light. Such benches should be substantially built, and have shelves and bins for

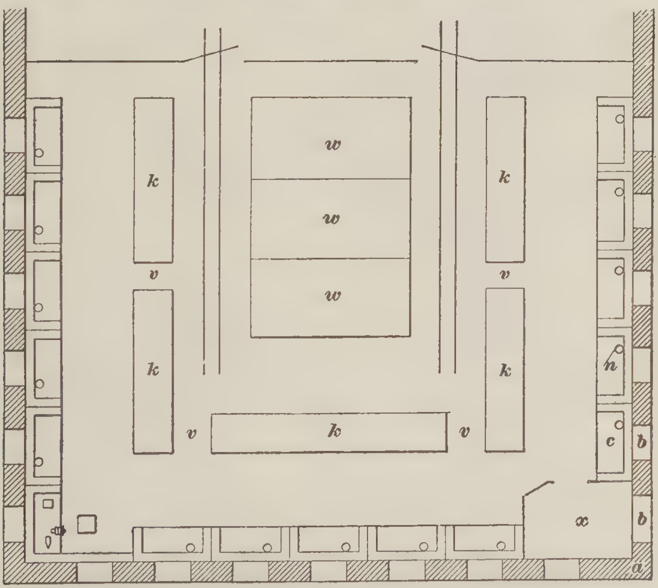


Fig. 26

core rods and wires, and drawers for tools and brushes. The top of the bench should be large enough to hold a liberal quantity of core sand and be fitted with a planed cast-iron plate. The core sand may be delivered through chutes *n*, which terminate about 1 foot or 18 inches above the benches. Irregular cores are mostly made by hand in special core boxes of wood or metal. The latter are preferable when large

numbers of cores are required, as they will keep smoother than the wooden boxes and are not so likely to get out of shape.

61. Core-Box Vise.—In Fig. 27 is shown an adjustable quick-acting vise or clamp for holding core boxes while the cores are being made. It is secured to the core-maker's bench *c*; two adjustable clamp screws *b* held in two movable arms *d* grip the core box *a*. Attached to the slide *g* is the needle *f*, which is used to vent the core *i*. The needle is withdrawn from the center of the core *i* by moving the slide *g* by means of the handle *j*. The clamp screws move outwards and release the core box when the pressure is relieved from the foot-lever *l*.

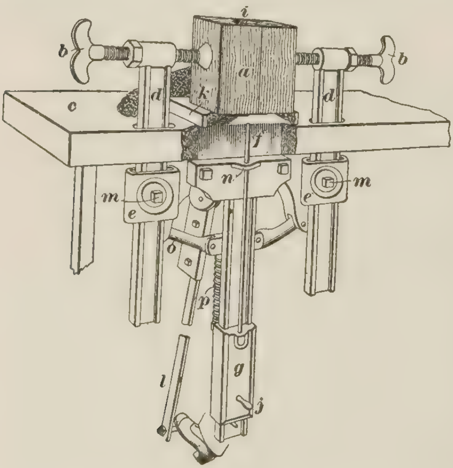


FIG. 27

62. Core-Rod Straightener. Core rods that have been used are nearly always crooked and in an unfit condition for storing; they should therefore be straightened when they are returned from the molding floor. In Fig. 28 is shown a machine designed for this purpose. The body of the machine contains a revolving straightening mechanism that is operated by a belt running on the pulley *a*. The crooked rods *b*, view (*a*), are made to enter the machine through hardened circular bushings *c* and pass out straight through similar bushings on the opposite side of the machine, as shown at *d*, view (*b*).

63. Wire Cutter.—A wire cutter of the form shown in Fig. 29 is a useful machine for a core room. It consists of a lever *a* that operates a shear blade *b* and cuts off the wire to any desired length when drawn through the holes *c*.

64. Core-Sand Mixer.—One form of core-sand mixer is shown in Fig. 30. It consists of a revolving screen *a* supported above a mixing barrel *b* in which are a series of blades or paddles *c*. The blades are fastened to a shaft *d* that carries the gear *e* on its end and is driven by a pinion on the end of the shaft carrying the tight and loose pulleys *f* and *g*. The screen is rotated by a sprocket-and-chain drive from the shaft *d*. The materials to be mixed are first fed into the upper end *h* of the screen and the screened material drops through directly into the mixing barrel *b*, while the rough material, such as stones and pieces of iron, rolls out at the lower end *i* and is carried away by the spout *j*.

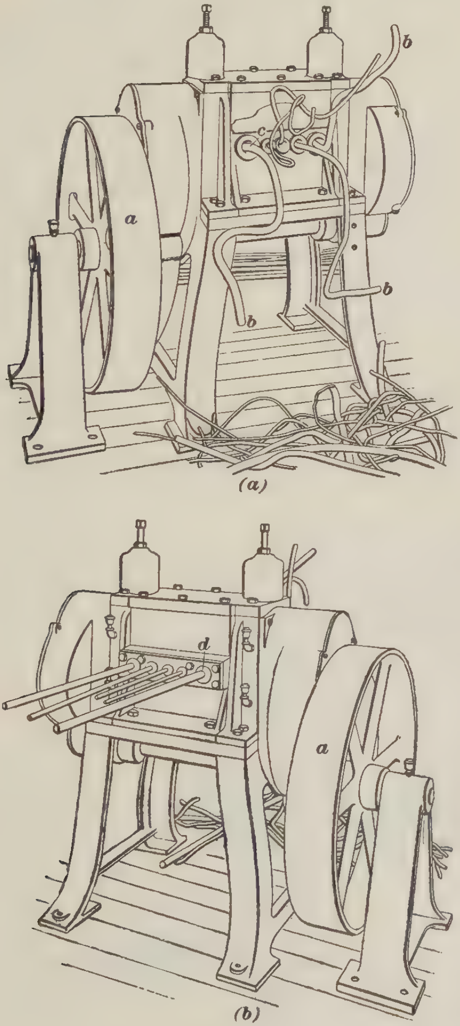


Fig. 28

65. The oil and water or other tempering liquids are run into the mixing barrel *b*, Fig. 30, through pipes and there are mixed with the materials by the action of the blades *c*. The blades are arranged in four rows on the

shaft d, which runs at a speed of about 25 revolutions per minute. Some of the blades are set to carry the materials toward one end of the mixer and the others are set to carry the mixture in the opposite direction. As a result, the mixing is very thorough. It requires from 3 to 4 minutes to mix and temper a batch of mixture. This mixture is then removed through an opening in the bottom of the barrel. The opening is closed by a gate that is operated by the lever k. The door l in the side of the mixing barrel is closed when the mixer is in action. It is shown lowered so that the blades and the interior of the mixing barrel may be seen.

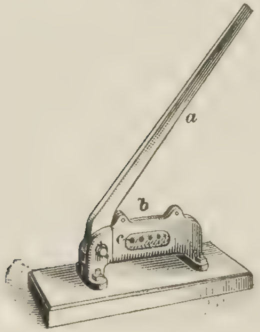


Fig. 29

66. Core Racks.—A core room should have conveniently

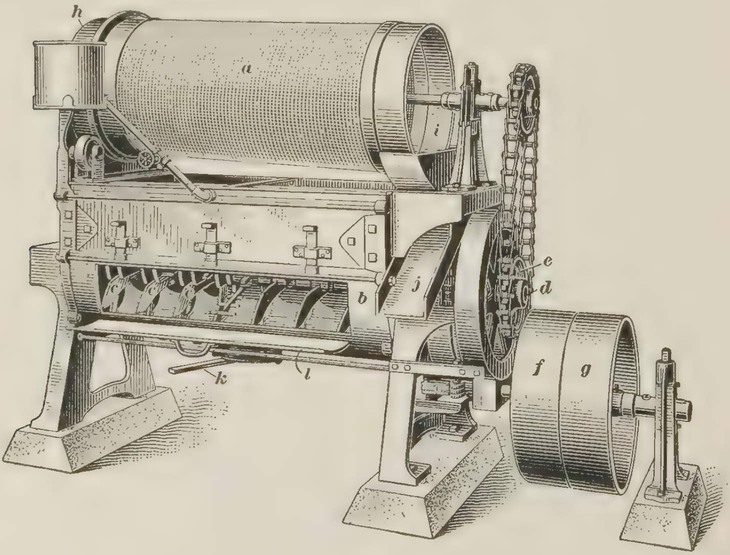


Fig. 30

located racks, shown at k, Fig. 26, with ample storage capacity equally accessible to the core makers and the oven tenders.

The racks are preferably arranged between the core benches *c* and the ovens *w*, with a wide passageway on both sides. The racks consist of a series of open and narrow shelves that permit the cores deposited on one side by the core makers to be reached by the men charging the ovens on the other side. The lower shelves serve for empty core plates and the upper ones for finished cores. The racks should have passageways *v* between them at intervals, to allow free communication between the benches and the ovens.

67. Core Plates.—The cores are placed on iron plates and deposited in an oven to be dried and baked. These core plates should have true planed surfaces. If warped plates are used for drying the halves of pasted cores, it will be found necessary to rub the faces of the cores together until they make a good joint. But this practice is not to be recommended, as it will be found that such cores are usually out of shape and not true to size, and consequently satisfactory castings will not be produced. Core plates should be drilled with small holes countersunk on the lower side. These holes will aid in both ventilating and drying and will decrease the weight of the plates. Cores of irregular shapes are preferably placed on drying plates with outlines of the same shapes as the bases of the cores, as true cores will thus be insured.

68. Small Core Ovens.—Ovens for drying cores may be either portable or stationary, and consist of iron or brick rooms provided with racks and shelves, or tracks. They should be arranged so as to be heated as easily as possible at an evenly distributed and constant temperature. Ovens are fired with any of the ordinary fuels, but gas or coke is preferable. A small portable oven is shown in Fig. 31 (*a*). It has shelves *a* fastened to the back of hinged doors *b*. The shelves are cast-iron gratings that allow a free circulation of the heat about the cores *e* that are on plates *d* in the oven. A baffle plate *c*, supporting the shelf and fastened to the door at right angles to it, serves to close the opening and prevent the loss of heat when the door is wide open.

69. In another form of oven the shelf is hinged at the middle, as shown in Fig. 31 (*b*), and the door itself serves as the baffle plate and closes the opening when turned through a half circle from its original closed position. The hinged form of shelf is desirable, as it can be brought into a convenient position to receive the cores or to remove them from it. The body of such ovens is usually of sheet iron made double, the space between the inner and outer walls being filled with some nonconductor of heat, or simply a closed air chamber that prevents quite effectively the loss of heat. The furnace is at the rear of the oven and the flues are arranged so as to distribute the heat evenly to the shelves. The stationary form of oven having either hinged or stationary shelves is usually set in brickwork and the furnace is located in the bottom or at the side, whichever is most convenient.

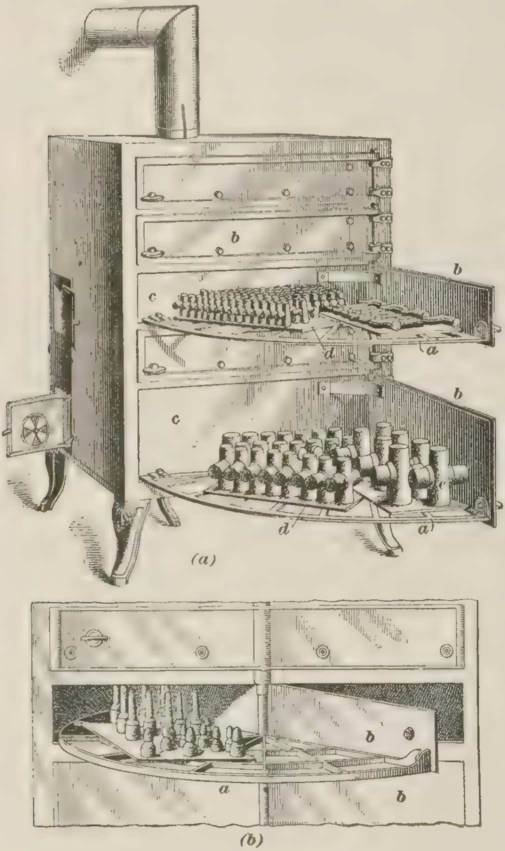


FIG. 31

70. Large Core Oven.—Large cores must be very thoroughly baked; therefore, brick ovens of the type shown in

Fig. 32 are used. The cores are placed on the shelves of a core-oven car *a* that is made of metal and supported by trucks running on a track *b* that extends into the oven. The track must be laid on a good foundation so that it will not yield under loads nor be affected by the heat of the oven. The opening through which the core-oven car enters the oven is closed by a metal door *c* that is rolled up or down by pulling on the chain *d*, which operates the gearing *e* and turns the shaft to which the upper end of the door is fastened. After the

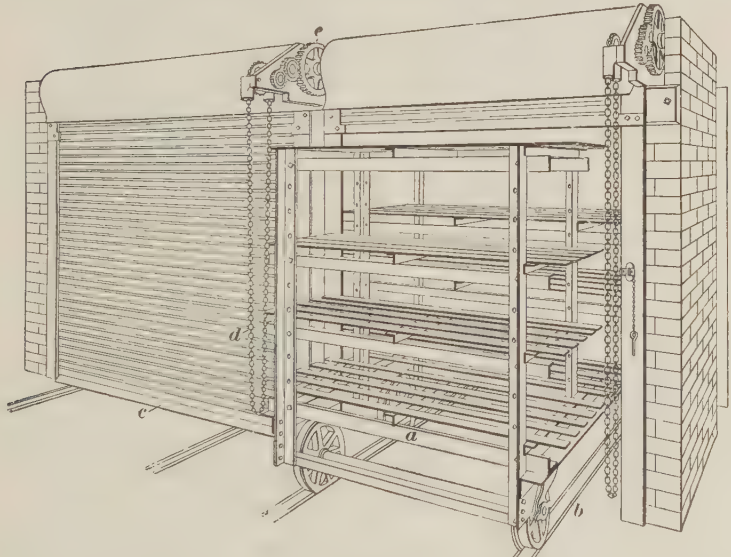


FIG. 32

loaded core-oven cars are rolled into the ovens, the doors are closed and the cars are left in the oven until the cores are baked. After the baking period, which may be from 12 to 48 hours, the cars are withdrawn, and the cores are removed from the cars with the aid of cranes and delivered to the proper departments. The firing pit of the oven is at the rear end, and the draft draws air through the fire-box, where it is heated, and carries it through runways below the tracks into the ovens through openings at the front. The temperature is observed by the use of a pyrometer and is regulated by dampers

adjusted by the fireman. The fuel is dropped into the fire-pit through chutes that are fed from the tops of the ovens.

71. Antifriction Trucks.—Some form of antifriction or roller bearings requiring no lubrication is used on the iron trucks of core-oven cars. In Fig. 33 is illustrated a truck without journal-boxes that is sometimes used for this purpose. The support for the car frame consists of a casting *a* having two lugs *b* at the ends, which serve as stops to prevent the axle *c* from rolling off the bearing. The proper proportion of the parts should be such that the distance *d* between the center of the shaft in its two extreme positions is to the distance the car is to be moved on the tracks *e* as the diameter of the shaft *c* is to the diameter of the wheel *f*. Some style of antifriction truck is also used in the large core and drying ovens in steel foundries where the entire molds must be dried before the metal is poured. For the heaviest work, especially in annealing furnaces, the trucks are moved on smooth iron balls that are laid in V-shaped tracks, the supporting side frames of the trucks being of a similar form, but inverted so as to fit over the rows of balls.

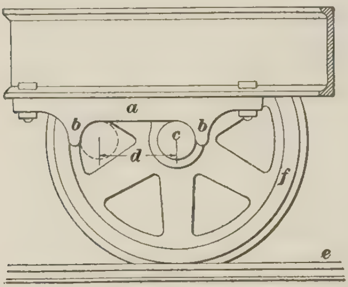


Fig. 33

72. Core-Making Machine.—Cores have only recently been made by machinery. While most cores are made by hand, many can be made better and cheaper by machinery, especially those cores with uniform cross-sections. As yet there is no universal machine suitable for all conditions; a greater variety of special appliances are required to produce the various shaped cores than to make the molds for the castings.

In Fig. 34 (*a*) is shown a machine for making cylindrical and prismatic cores of various uniform cross-sections. The machine is operated either by hand or by power, and consists of a base *a* supporting the movable parts and the vertical hopper *b* for holding the core mixture. The hopper is made

with the half c removable, for convenience in cleaning and to aid in adjusting the feeder spindle d and changing the bit e in the machine. The bit is shown in an enlarged view in (b). A tube f, having a hole of the same diameter as the core to be made, is fastened into the socket g by means of a setscrew. The machine is supplied with a set of tubes of different sizes

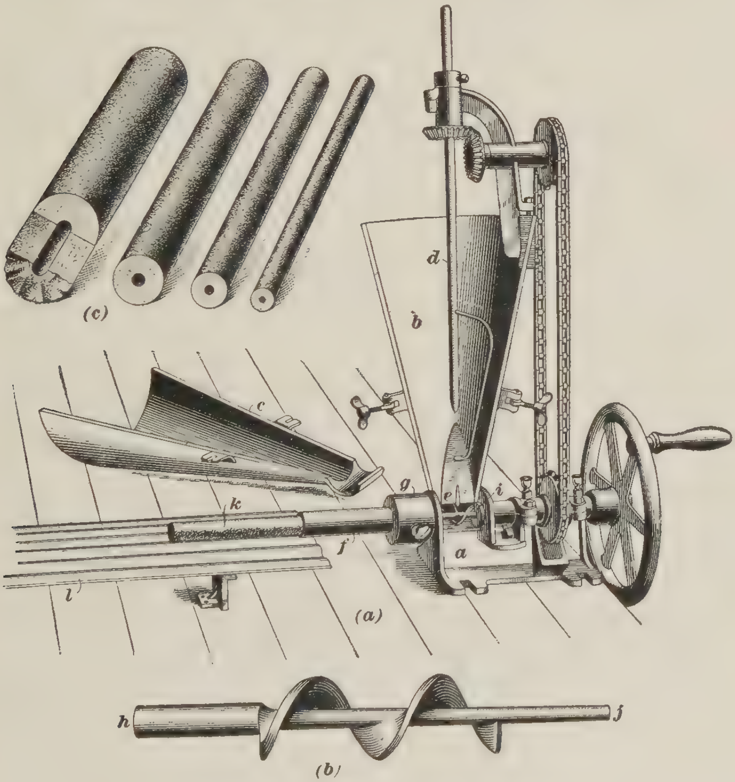


Fig. 34

with bits to work with them. To operate the machine, a tube having the desired opening and a bit corresponding to it are selected; the tube is inserted into the socket g, and the shank h of the bit is inserted in the socket of the crank-shaft i. The point j of the bit extends into the center of the opening in the inner end of the tube f. The core material,

which should be thoroughly mixed and sifted, is fed into the hopper.

73. The proportions of the mixture used in such a machine may vary considerably. In some work a mixture of 6 quarts of core sand, 1 quart of flour, and 1 gill of raw linseed oil may be used, whereas for other work as much as 12 to 15 parts of sand to 1 of flour is used. The use of oil enables cores to be kept in stock indefinitely and also lubricates the machine. When the bit is revolved, it forces the material from the hopper through the tube and forms a continuous straight core vented from end to end through the center. The core *k*, Fig. 34 (*a*), is received on a metal tray *l* placed in a horizontal position under the outer end of the tube *f*; the shape of the grooves in the tray should conform to the form of the core. The core is cut into suitable lengths and dried in the oven. The relative sizes of some of the cores made by this machine are shown in (*c*).

74. Machines are sometimes used for making green-sand cores. The different machines vary greatly, sometimes consisting simply of adjustable boxes, various portions of which can be quickly and easily withdrawn from openings in or removed from about the core when it is completed. In some cases special core barrels are also used, and the machines support these while the sand is rammed about them. In reality these green-sand core machines are simply molding machines used for molding green-sand cores and they may be similar to any one of the several classes of molding machines used in green-sand molding.

MACHINE MOLDING

PRINCIPLES OF MOLDING MACHINES

CLASSIFICATION AND LIMITATIONS

1. Molding Operations.—The making of a sand mold, whether it is done by hand or by machine, consists of seven fundamental operations, which are: (1) Putting the flask over the pattern on the joint surface; (2) filling the flask with sand; (3) ramming the sand; (4) turning the mold; (5) drawing the pattern; (6) setting the cores; (7) closing the mold.

Machines are made that perform some of these operations more or less perfectly; but those machines which put the flask over the pattern, set cores, and close the mold usually do so only with a considerable amount of manual assistance and in any of these operations, whatever is done, is usually a part of the more perfect performance of one of the other functions of the machine. These operations are therefore of such secondary importance that they will be described only in connection with other and more important functions.

2. Machines constructed for ramming the sand are made to work on various principles. In some instances, no more assistance is needed from the operator than the turning on and off of the power; while with others the operator does more or less of the work. The same may be said of machines used for drawing the pattern. Machines that close the mold usually do so as the reverse operation to the one that draws the pattern, and they will therefore be explained in that connection.

3. Classification of Molding Machines.—Molding machines may be classified as *ramming machines* and *pattern-drawing machines* and each class may be subdivided into a number of subclasses, according to the manner in which the operations are performed. Machines that combine these or other molding operations are generally called *combination machines*. Ramming machines may tamp, squeeze, jolt, or roll the sand, or the sand may be dropped into the mold in such a way that it is packed by gravity. In a like manner, patterns are drawn up or down from the parting surface of the finished mold with various aids for so doing.

4. Molding-Machine Limitations.—No very definite line can be drawn between work that can be economically done on a molding machine and that which cannot. Molding machines are especially well adapted to the molding of work that is to be produced in large quantities. If, however, the same pattern that would ordinarily be used for hand molding can be used on the molding machine with but little expense for fitting to the machine, a molding machine may possibly be used for a few molds only. On the other hand, when special patterns have to be made or many cores more than for hand molding are required, the use of a molding machine might not be warranted.

5. The kind of machine must also be considered in deciding whether a mold can be economically machine made, as each machine has its own limitations. A squeezer rams the sand by squeezing the mold, but it cannot pack the sand beyond a certain depth. Other machines will ram deeper molds than the squeezer; for example, there is no known limit to the depth of mold that can be jolt-rammed.

6. The manner in which the pattern is drawn also limits the usefulness of some machines. Machines that lift the pattern out of the sand or lower the mold away from the pattern are, as a rule, especially well adapted to the molding of the drag, because the mold does not have to be turned over to be ready for the cope. A machine, however, that lowers the

FIG. 1

pattern or lifts the mold is better suited to the molding of the cope, since the mold is ready to set on the drag without being turned over. Some molds have to be turned over to be blacked or patched and they are, of course, an exception to the rule just stated. The limits of usefulness are much narrower for a machine that rolls the pattern out of the sand than for those that draw by any of the other methods.

RAMMING MACHINES

7. Pneumatic Rammers.—A form of pneumatic rammer for light work is shown in Fig. 1 (*a*). It is operated by air under a pressure of 40 to 90 pounds per square inch. Some authorities object to classing the pneumatic rammer as a molding machine, because it requires so much assistance in the performance of its work as hardly to merit that distinction. It consists of a cylinder *a* supported at the middle on trunnions *b*, that have their bearings in a frame *c*. This form is provided with two rammers *d* and *e*, one at each end *f* and *g* of the piston rods, which extend beyond the ends of the cylinder. The rammer *d* is a peen and the other *e* a butt rammer. Either of these may be used at will by swinging the cylinder on its trunnions so that the desired rammer stands downwards. The stroke of the piston is regulated by an automatic reversing valve. The air is supplied through a hose *h*. A wire rope *i*, which passes over a pulley and carries a counterweight, is attached to an eyebolt *j* in the top of the machine.

One man operating a pneumatic rammer can strike from 200 to 300 blows per minute. It is equally economical and applicable for green sand, loam, floor, or machine work. The blows are struck with uniform pressure and hence the ramming can be done more evenly and far better by using the pneumatic rammer than by hand.

8. A portable form of pneumatic rammer that is held by handles attached to the cylinder is shown in Fig. 1 (*b*). This form has only one rammer *a*. The end of the piston rod is so constructed that either a peen or a butt rammer

may be attached to it. The flow of air is controlled by a valve operated by a small trigger in the right-hand handle.

9. Another form of pneumatic rammer that is especially serviceable for backing up large and deep molds is shown in Fig. 1 (*c*). This rammer is attached to the supporting frame *a* by means of a long screw *b*. By rotating the rammer by means of the handles *c*, while it is operating, it is lowered or raised as required to allow the tamping plate *d* to reach the sand in the molds. The hollow screw *b* is used to conduct the air to the cylinder from the hose that is attached by means of a swivel coupling *e*. The rammer is attached to a hoist on the trolley of a jib crane or some similar support that will permit the rammer to be easily shifted over the surface of the mold by means of the hook *f*.

10. A small pneumatic rammer is used on bench work. It may be held in the hand, or it may be mounted on a swinging support arranged to be moved over the surface of the mold that is being rammed. Some pattern-drawing machines do not ram the sand, and when these are used it may be possible to utilize a pneumatic rammer advantageously.

11. Hand-Squeezer Molding Machine.—As already mentioned, machines that compress the sand in the mold by squeezing, are commonly called *squeezers*. Such machines are suitable for molding flat articles, as builders' hardware, stove lids, washers, wrenches, etc., which are molded mostly in snap flasks. The object of the machine is to obviate the hand-ramming operation and to increase the output.

12. A machine for squeezing, or pressing, the molds is shown in Fig. 2. It consists of a frame with a table *a* to support the flask, and a lever *b* by means of which the presser head *c* is lowered against the presser board *f*, which rests on the surface of the molding sand, pressing it into the flask. The illustration shows the sand being pressed into the drag *d*, which is placed over the patterns on a match board *e* on the table *a* of the machine. After pressing the sand in the drag, the presser head *c* is thrown back, the mold turned over, the match board removed,

parting sand applied, and the cope *g* placed over the drag *d*. The sand is then pressed in the cope in the same manner as described for the drag. The presser head is then thrown back out of the way, the sprue is cut, and the pattern rapped by striking against a pin that is held in the left hand so as to stand in the sprue with the lower end in contact with the pattern; after which the flask is separated, the pattern withdrawn, and the mold placed on the floor to be poured. The

FIG. 2

power is applied to the lever *b* by the operator simply straightening his arm and putting his weight on it, pressing every mold alike, and with little care or judgment on his part. The shelves *h* are used for holding brushes, sprue cutters, and a box *i* of parting sand, and the upper shelf especially for holding the match or presser boards. The table *j* is utilized to hold parts of a flask, or molds, or the match boards, etc.

This type of molding machine is portable, being easily moved about the foundry floor on the rollers *k*. A modification

of this machine is made with the feet spread very wide apart so that it will straddle the sand pile.

13. Another form of mold squeezer is shown in Fig. 3. In the machine illustrated in Fig. 2 the presser head is lowered on the sand, while in the machine illustrated in Fig. 3 the sand is compressed in the flask between the presser head *a* and the table *b* by the vertical movement of the table; this operation is performed by means of the lever *c* turning the

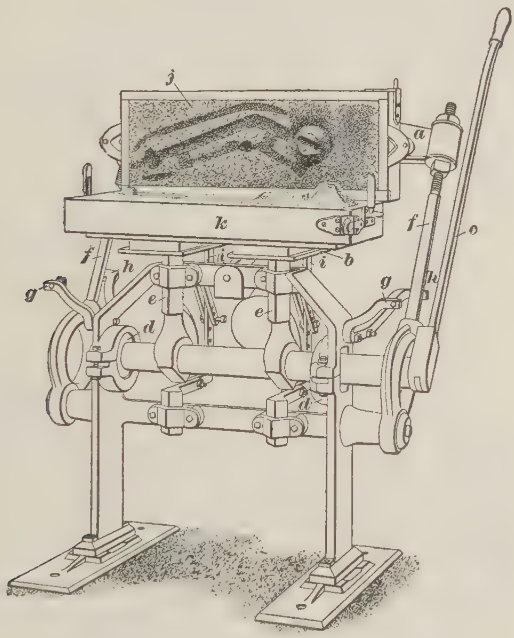


Fig. 3

shaft that carries the eccentrics *d*, and thus lifts the rods *e* that support the table *b*. The height of the presser head is adjusted by means of the thread and nuts on the upper ends of the side rods *f*. The stops *g* determine the position of the side rods *f* when the presser head is over the mold, and the stops *h* support the rods when the presser head is thrown back so that the mold can be opened. Two brackets *i* support a shelf at the rear of the table *b* for holding the cope *j* when

the mold is opened to remove the pattern, as shown in the illustration; the presser head moves back far enough to give ample room for the cope to rest edgewise on the table, back of the drag *k*. The pattern in the mold is for the burner of a gas stove.

14. Power-Squeezer Molding Machine.—Several forms of squeezing machines are arranged to operate by means of compressed air. One of these machines is shown in Figs. 4

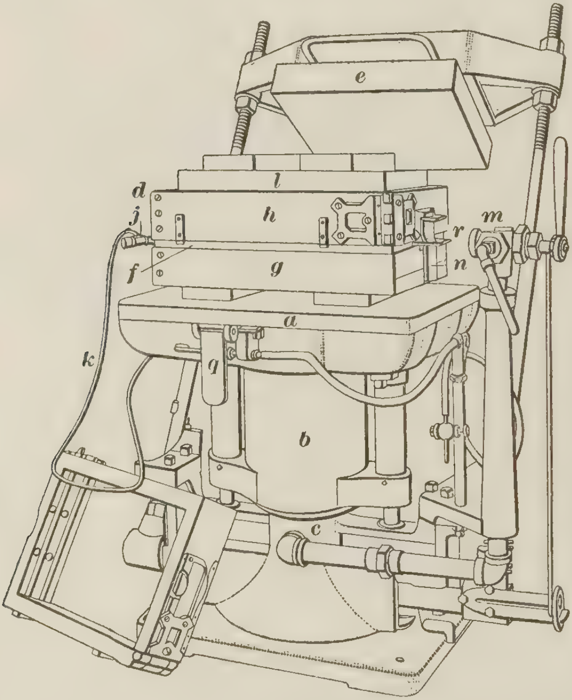


FIG. 4

and 5. In this machine, the table *a* is attached to a cylinder *b* that slides over a stationary plunger *c*. The table *a* moves upwards when compressed air is admitted to the cylinder and presses the sand in the flask *d* between the table and the presser head. In the illustrations, the presser head *e* is shown tilted back to enable the flask to be put in position or removed.

An air pressure of about 75 pounds per square inch is used. The ordinary solid and gated patterns are made available for use on this machine by attaching them to a *vibrator frame f* or by means of match plates. The vibrator frame is shown in detail in Fig. 6. This frame is placed between the match *g* and drag *h*, as illustrated in Fig. 4, while the drag is being made, and between the cope *i* and drag *h*, as shown in Fig. 5,

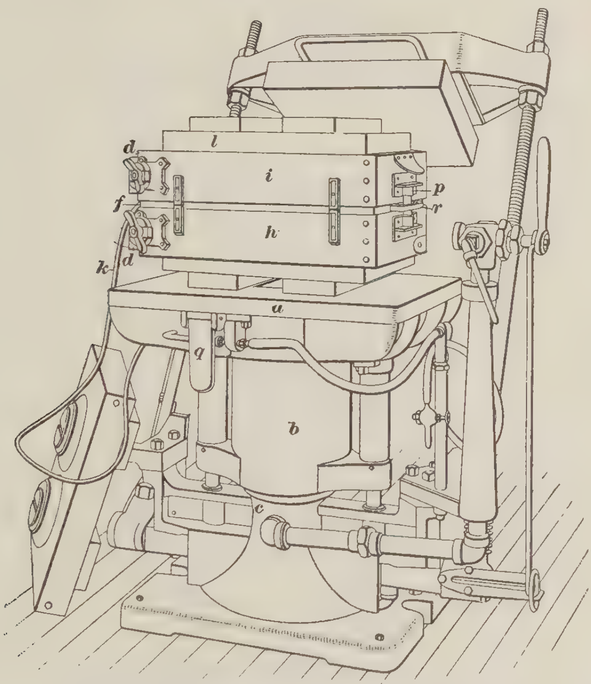


Fig. 5

while the cope is being made. The vibrator *j*, which is attached to the corner of the frame, as shown in Figs. 4 and 6, consists of a small plunger arranged to vibrate back and forth between two hardened anvils in a cylinder. When compressed air is supplied to the vibrator through the hose *k*, Figs. 4 and 5, its action sets up a sharp tremor in the frame and patterns, and the patterns are lifted from the sand without hand rapping.

To operate the molding machine, the match *g* with the vibrator frame *f* and patterns are laid on the machine table *a*. The drag *h* is placed in position, filled with sand, and pressed. To press the sand, the presser board *l* is placed on the drag,

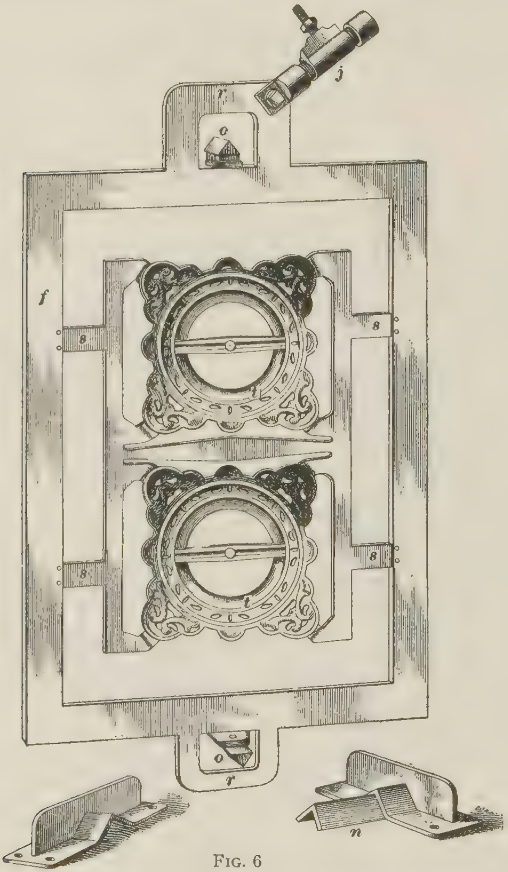


Fig. 6

the presser head *e* is swung over the table, and the air admitted to the cylinder by means of the three-way cock *m*. After squeezing the mold, the air is exhausted from the cylinder and the table is lowered by gravity; the presser head is pushed back and the match and drag rolled over on the table by hand

in the usual way; the match is removed, parting sand applied to the face of the mold in the drag, and the cope placed in position, filled with sand, and pressed in the same manner as described for the drag. Snap flasks are generally used, though interchangeable solid-iron flasks can be adapted to the machine.

In order that the different parts of the flask and the vibrator frame may come together accurately in forming the mold, special **V**-shaped pins *n* and *o*, shown in Fig. 6, are used. The drag pins *n* slide over the vibrator frame pins *o* and enter the sockets *p* of the cope. After ramming the cope, the presser head is thrown back and the flask left in position for the cope to be removed. The sprue is cut either by hand in the usual way, or in some cases automatically by means of sprue cutters attached to the presser head. A lever *q* under the edge of the table *a* admits air to the vibrator. When the operator grasps the cope with his hands, he presses the lever *q* with his knee and the cope is lifted while the vibrator is running; the vibrator is also operated while the frame is being lifted off, the lifting being done by means of its two handles *r*. The patterns are guided vertically from the sand by means of the **V**-shaped pins *o*, attached to the frame shown in Fig. 6, and can be easily and accurately replaced in the mold if necessary. The prints in the mold made by the bars *s*, which are used to attach the patterns *t* to the frame, as shown in Fig. 6, must be filled with sand before the flask is closed and poured, unless they are used as core prints and closed by the cores.

15. A high trunnion power squeezer is shown in Fig. 7. The most unusual feature in this machine is the manner in which the pressure head is turned back when not in use. The presser head in view (*a*) is swung back out of the way and it is held in this position by the spring *a*, which also acts as a counterbalance when the presser head is turned down to the service position illustrated in (*b*). When acting as a counterweight, the spring facilitates the turning of the presser head up out of the way. When the presser head is in the service position, the link *b* is hooked under the lug *c* so that

the presser head will not be forced up when power is applied. Air is admitted to the squeezer cylinder through the throttle valve *d*, which is controlled by the handle *e*. The squeezer cylinder is below the table *f*, which is lifted when the mold is squeezed. The blow valve *g* is used in place of the bellows

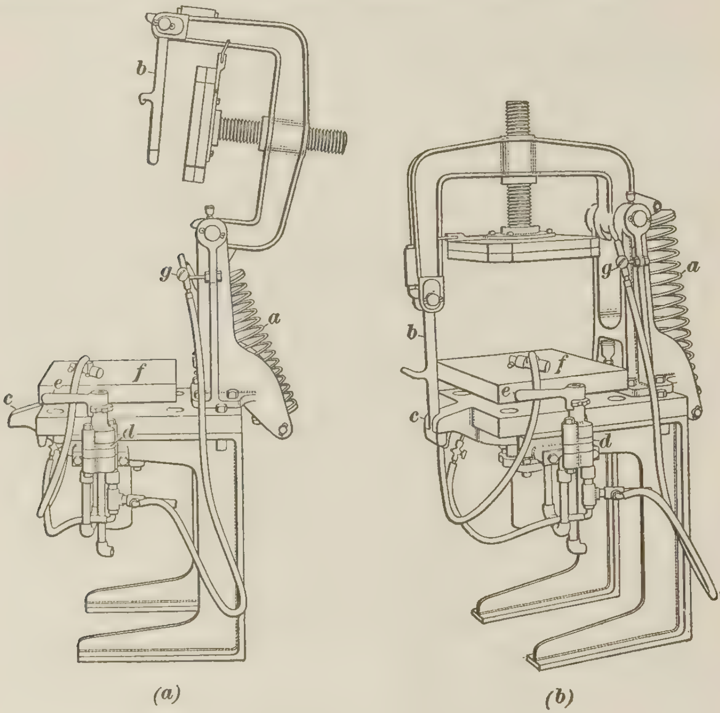


Fig. 7

commonly employed in hand molding to remove loose sand from the mold or pattern.

16. When squeezer machines are used, the sand is made most dense at the surface of the squeezer head, the density being less at points farther from the squeezer head. Such machines are therefore not suitable for use with very deep molds. When the molds are very large, the amount of pressure needed to pack the sand sufficiently becomes excessive, requiring that the machines be very large and heavy.

17. Jolt Ramming Machines.—Many molds that are either too large or too deep to be successfully handled on a squeezer molding machine may be rammed on a jolt machine. The simplest form of jolt machine consists of a flat table on which is placed the mold that is to be rammed. The table is arranged so that it may be raised slightly and allowed to drop on an anvil that rests on a heavy foundation. The jar, or jolt, produced by dropping the table compresses the sand in the mold. Such machines are therefore called either *jarring machines* or *jolt machines*.

18. A jolt molding machine is shown in Fig. 8. The table *a* is supported on the plunger in the cylinder *b*. When air is

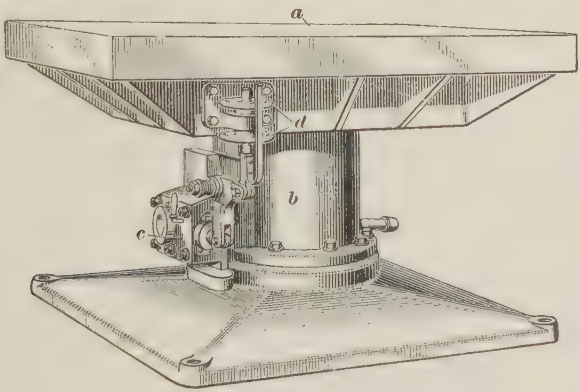


Fig. 8

admitted to the cylinder, the plunger and the table are raised until the valve in the box *c* is shifted and the air is exhausted, thus allowing the table to drop and strike on the top of the cylinder. The jar thus received by the table and the mold that may be on it rams the sand. The height to which the table is lifted before the air is exhausted and it is allowed to drop may be regulated by the hand wheels shown at *d*. If desired, this operation may be performed while the machine is running.

19. An air-operated, jolt ramming machine that differs somewhat from the one just described is shown in Fig. 9. The table *a* is bolted to the top of the plunger *b*, which works

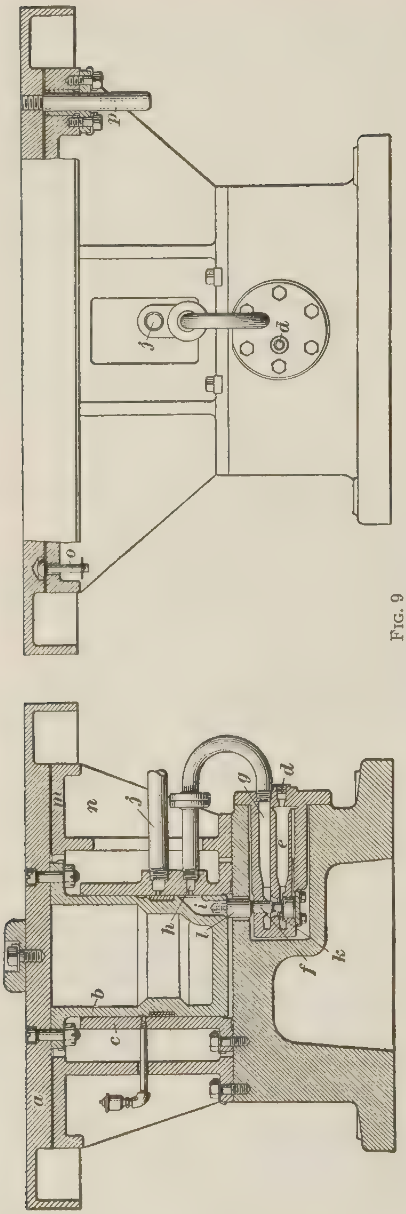


FIG. 9

in the cylinder *c*. The air-supply pipe is attached at *d*, from which point the air goes through passage *e*. There is an opening from *e* into the annular space around the stem of the valve *f*, and the air passes through this opening into the port *g*. From this passage *g* the air passes through the curved pipe to *h*, which registers with the passage *i* in the piston when the piston is down, and thus it enters the cylinder under the piston and raises the piston and table. When the piston has nearly reached the top of its stroke, the port *h* is closed so that no more air can enter the cylinder. The table, however, continues to rise on account of its momentum and the expansion of the air already in the cylinder. Soon after the port *h* is closed, the exhaust port *j* is opened, and air is exhausted from the cylinder.

Up to the time that the exhaust port is opened, the valve *f* is air-balanced, that is, the air pressure tending to lift the valve is equal to that pushing it

down. As soon, however, as the exhaust port is opened, the upward air pressure on the valve exceeds the downward pressure and the valve is moved up against the conical seat *k*, thus shutting off the air supply so that air will not again enter the cylinder when the port *h* is opened by the downward motion of the plunger. Just before the plunger reaches the bottom of its travel, the plug *l* strikes the valve *f*, pushes it down off the valve seat *k*, and readmits air to the cylinder.

When the table is dropped, it strikes the surfaces *m*, near the outside of the table. Hence, the table need not be made as heavy as when the area of the surface on which the table drops is small and near the center. The anvil surfaces *m* are, however, supported by ribs *n*.

In order to prevent the table from rebounding, as it would be likely to do if it struck directly on the anvil surfaces *m*, a few pieces of sheet metal are placed between the table and the anvil. These sheets are not fastened tightly to the anvil, but they are held from being lifted too far off it by bolts like *o* and the table is kept from turning by the guide pin *p*. A projection in the center of the table fits into a suitable socket on the back of the pattern board, so that the weight of the mold is near the center of the table. The severity of the blow, and, consequently, the ramming effect, is controlled by regulating a valve in the exhaust pipe. The nearer the valve is to the closed position, the less is the ramming effect of the blow.

20. Another jolt ramming machine is arranged so that the table is raised by a cam on the end of a shaft, the cam being shaped so that it allows the table to drop when it has been raised to a predetermined height. The shaft on which the cam is mounted is driven either by an electric motor or by a belt. The drop in a machine of this kind cannot be varied; consequently, the work for which the machine is adaptable is somewhat limited, as will be shown presently.

21. Hardness of Jolt-Rammed Molds.—When a jarring machine is arranged so that the table is lifted to a certain height before it drops, the sand can be packed only a certain

amount, and the running of the machine, after that degree of hardness has been reached, does not ram the sand any harder. The degree of hardness of the mold may be varied within certain limits by varying the length of time that the mold is jolted, and beyond that limit the hardness can be increased only by increasing the height of the drop. It is advantageous with some molds to ram lightly at first and then to follow with a few heavy blows. This result may be accomplished with the air-operated jolt machine by increasing the lift of the table toward the last or by reducing the throttling of the exhaust, thus allowing the table to fall harder. By means of a jolt molding machine the sand is packed most densely at the surface of the pattern and least at the surface of the mold farthest from the pattern. These molds may therefore require some hand ramming on the back, especially if the flask is to be turned over.

22. Jolt-Machine Foundations.—Jolt machines are made in sizes that permit very large flasks to be rammed. The shock produced by dropping a heavy weight, as in ramming a mold on a large machine, produces vibrations that are felt a great distance from the machine. A heavy foundation tends to lessen the severity of these vibrations which are sometimes troublesome, especially on soft ground, because they shake portions of the copes loose after the flasks have been closed. Some makers of jarring machines advise the use of a foundation containing at least 2 cubic feet of masonry per square inch of lifting-cylinder area, and it is usually explained that a larger foundation is better. A foundation that is too small may recoil after it is struck and cause the table to rebound. If the table rebounds, much of the ramming effect of the first impact is lost; thus it may not be possible to ram hard enough to permit turning the mold over after the pattern has been drawn.

23. Shockless Jarring Machine.—A shockless machine is shown in Fig. 10. The table *a* is raised by admitting air into a cylinder on which it is supported. The flow of air to and from the lifting cylinder is controlled by a valve in

the cylinder *b*, which is in turn moved by air pressure that is controlled by an auxiliary valve in the small cylinder *c*. The auxiliary valve is attached by rods to the lever *d*, which is thrown one way or the other by the arm *e* that moves with the table. The position of the arm *e* may be varied by turning the shaft to which it is attached. This turning may be done by a series of rods, one of which is shown at *f*, that lead to a place within convenient reach of the operator.

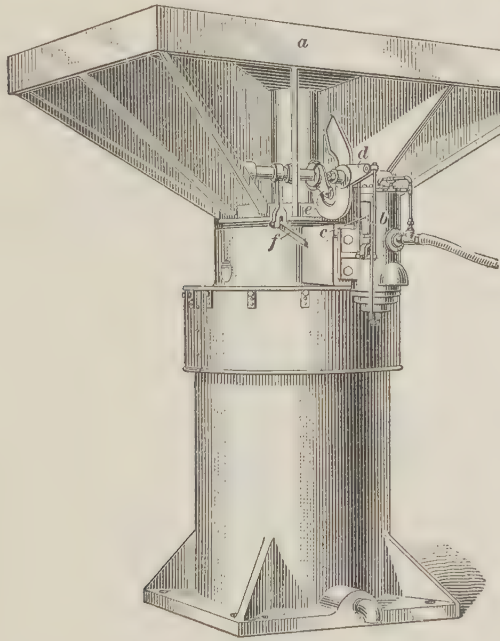


FIG. 10

24. The machine illustrated in Fig. 10 is shown sectioned in Fig. 11. All letters that appear on Fig. 10 and Fig. 11 refer to the same parts. The table *a* is the top part of a cylinder, which fits over the plunger *g*. The plunger *g* is part of the anvil *h*, which is supported on springs *i* in the cylinder *j*. The weight of the table *a* is therefore supported on the springs *i*, which are somewhat compressed by it. When the machine is in the position shown, air is being admitted

to the space above the plunger g and the table is rising. The arm e is about to move the lever d, which will result in moving the main valve in b. When the main valve is shifted, the

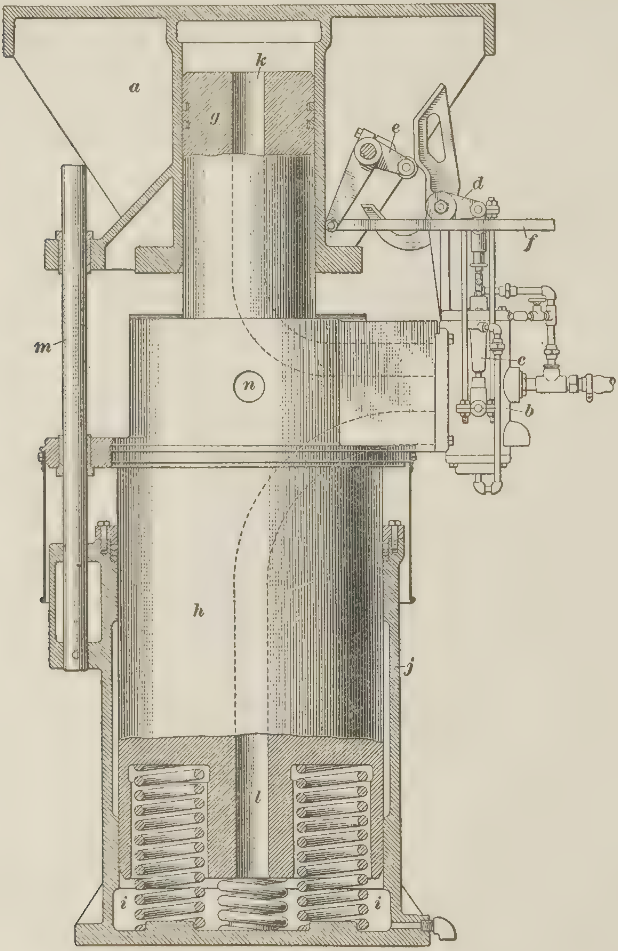


Fig. 11

air will be cut off from the space above g and it will be exhausted through passages k and l into the space below the anvil. Relieving the air pressure above the plunger g removes some

of the weight from the anvil and the springs *i* therefore push it upwards. The action of the springs is assisted by the pressure of the air acting on the bottom of the anvil. The result of the combined action of the springs and air is that the anvil rises to meet the table, which is stopped by the blow and without shock to the foundation. The rod shown at *m* is a guide to keep the anvil and table from turning and getting the valve mechanism out of alinement, and the hole *n* provides a crane hold when the anvil is to be lifted from the base.

25. Electric, Jolt Ramming Machine.—A jolt ramming machine is shown in Fig. 12. It resembles the air-operated machine illustrated in Fig. 9 except as will be explained.

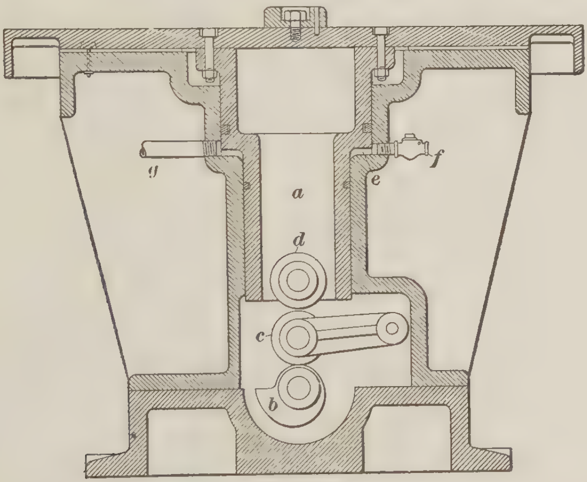


Fig. 12

The table that rests on the plunger *a* is raised by the cam *b*, which lifts roller *c* against *d*. The severity of the blow is controlled by cushioning the fall of the plunger. The plunger is not of the same diameter throughout; therefore, there is an annular space left at *e*. When the plunger rises, air is drawn into this space through the check-valve *f*, and when it falls the air is expelled through the pipe *g*. A globe valve is placed in the exhaust pipe *g*, where it may easily be reached by the operator. The fall of the plunger may therefore be

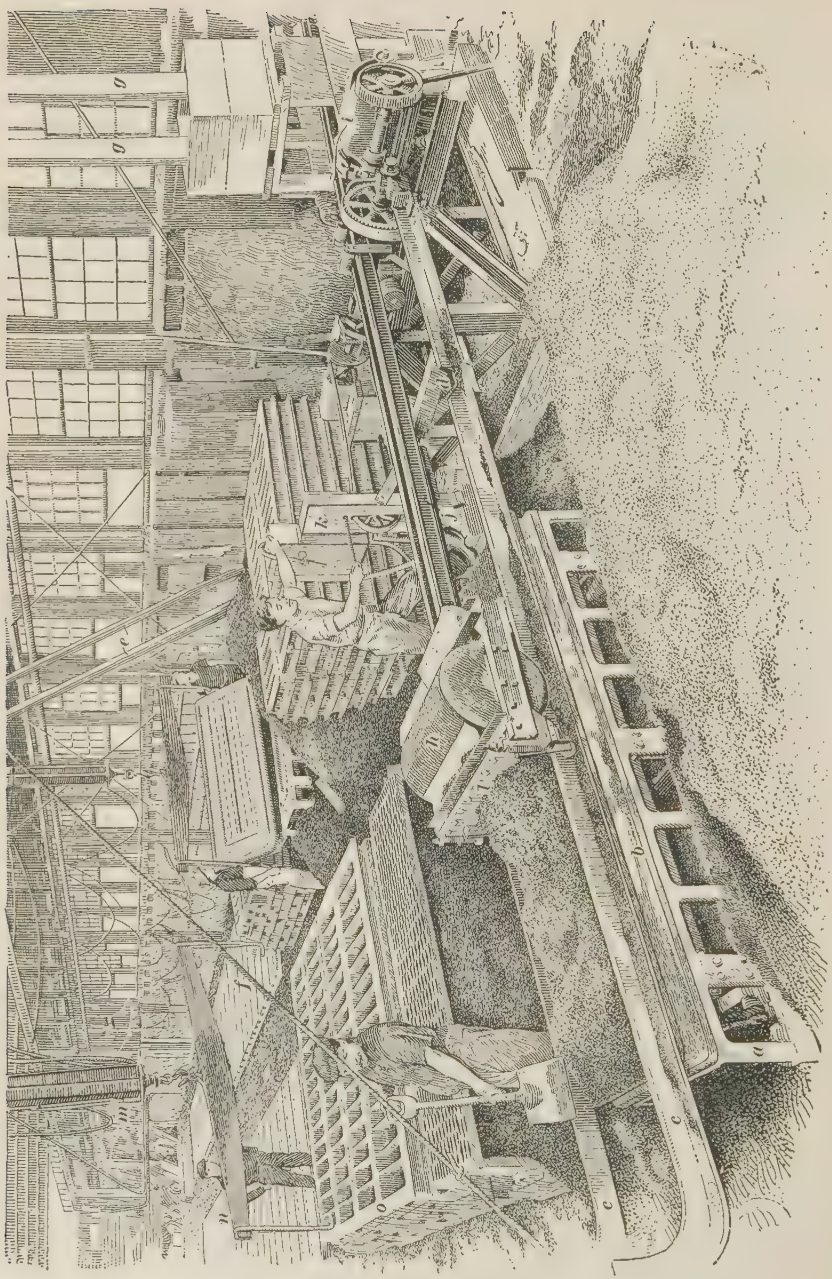


FIG. 13

cushioned so as to regulate the blow as desired. This type of machine is usually operated by an electric motor and it is therefore called an electric machine.

26. Roller Ramming Machine.—The roller ramming machine, shown in Fig. 13, rams molds that are too long for a squeezer machine and not deep enough for a jolt ramming machine. The pattern is permanently set on the bed *a*, which serves as a pattern plate. The flask *b* is then put in position, and the track *c*, which is hinged at *d* and has been swung up out of the way as shown at *e*, is let down on the flask. The raising and lowering of the track is facilitated by a counterweight that is attached to the end of the rope *f* and slides between the guides *g*. When the track is in position on the flask, parting sand is sprinkled over the pattern and the flask is filled with sand that is heaped well above the tops of the rails; the roller *h* is then passed over the mold two or three times. Grooves near the ends of the roller *h* fit over the rails and guide the roller as it is moved back and forth by the electric motor *i*, which works through gearing on the beam *j* and is controlled from the stand *k*.

The hardness with which the sand is packed in the mold is determined largely by the quantity of sand that is piled on top. In order that all parts of the mold may be packed uniformly, the roller is preceded by a strike bar *l*, which leaves the same depth of sand all along the mold. When it is desirable to ram one part of the mold harder than another, the strike board may be shaped to have a greater depth of sand over the part that is to be packed hard.

When the sand has been packed, the track is lifted out of the way, the surplus sand is scraped off the back of the mold, and the mold is carried by the air hoist *m*, which runs on an overhead track, not shown, to a position on the casting floor *n*. Empty flasks in which molds are to be made are shown at *o*.

The distribution of the ramming effect produced by the roller ramming machine is similar to that produced by the squeezer. That is, the sand is packed hardest on the back of the mold next to the roller and softest next to the pattern.

For this reason, the roller machine cannot be used satisfactorily with molds that are more than 10 inches deep nor with a pattern that has an irregular surface.

27. Gravity Ramming Machine.—When ramming by the gravity method, the sand is packed into masses that are dropped from a height of 8 or 10 feet into the mold. By the use of a machine of this type, the sand is packed into a mold of any depth and has nearly the same density throughout. Masses of sand that fall on the back of the mold may have the fall somewhat cushioned by the sand that is already in the mold, and they will therefore not be packed quite so hard as the sand that falls directly on the pattern. This cushioning effect may, however, be overcome to a considerable extent by dropping sand on the back of the mold until it is well heaped up and then striking off the excess sand. This type of machine is described more fully later.

PATTERN-DRAWING MACHINES

28. Pattern Drawn Up From the Joint.—A machine for lifting and guiding from the sand a pattern that is mounted on a match board is shown in Fig. 14. The machine has four legs *a* that fit holes in the match board *b* and rest on the joint edge of the flask. The hooks *c* engage pins on the edge of the match board and lift it and the pattern when the shafts and the cranks *d* attached to them are turned. The wheels *e* and *f* are connected by steel tapes *g*, the ends of which are riveted to the rims of the wheels. The two shafts are therefore made to move at the same rate and to draw the pattern straight from the sand. The legs *a* also guide the pattern and match board and keep them from swinging back and forth. Although a pattern might be drawn by working only one of the levers *h*, it is better that both should be worked at the same time. When only one lever is used, the end of the pattern farthest from it is liable to sag and cause trouble, especially if the pattern is heavy and has very small draft. When it is clear of the sand, the pattern and machine may be lifted off the mold by hand or by crane.

29. Pattern Drawn Down From Joint.—Machines that draw the pattern downwards from the joint are more liable to break the mold, unless the sand is supported in some way, than machines that draw the pattern up. This tendency is especially marked with patterns that are deep and have but little draft. In order to prevent the breaking of the mold when the pattern is drawn, use may be made of a *stripping plate*, which is a plate having a hole through which the pattern is drawn. The shape of the hole follows the outline of the pattern. A stripping plate may be used when the pattern

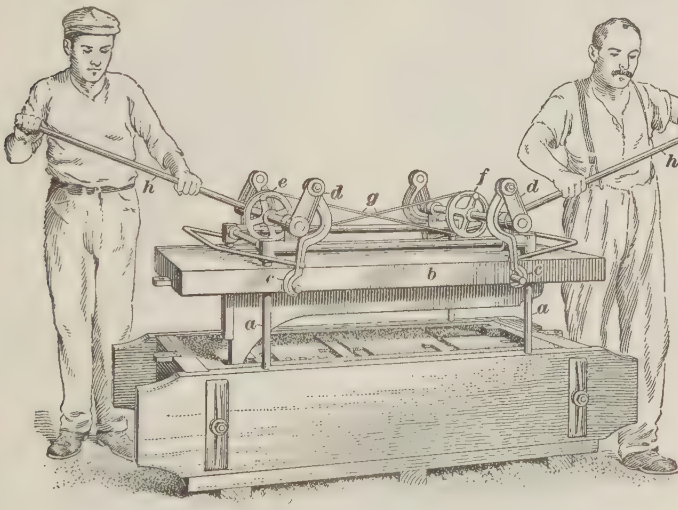


FIG. 14

is drawn up from the joint of the mold; but it is not needed as often as when the pattern is drawn downwards.

30. The patterns for brake shoes for railway cars and stripping plates for them are shown in Fig. 15. Two stripping plates are used, one for the cope pattern and one for the drag. Each of the plates shown has two patterns, so that each of the finished molds contains two brake shoes. The patterns are shown at *a*, view (*a*), and the stripping plate at *b*. The stripping plate also serves as a pattern board, so that the flask is inverted over the pattern in the usual way.

The pattern may be drawn either by holding it stationary and lifting the stripping plate and mold, or the stripping plate and mold may remain stationary and the pattern may be drawn downwards.

31. The patterns for the drag side of the brake shoe are shown at *a*, in view (*b*), and the stripping plate at *c*. Each

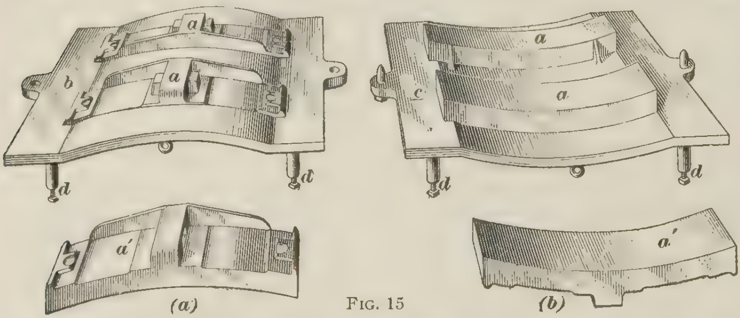


Fig. 15

of the stripping plates stands on four feet, two of which appear at *d*. Two views of the brake shoe are shown at *a*′, views (*a*) and (*b*).

Owing to the fact that projections, especially on the cope pattern, extend quite deeply into the mold, all parts of the

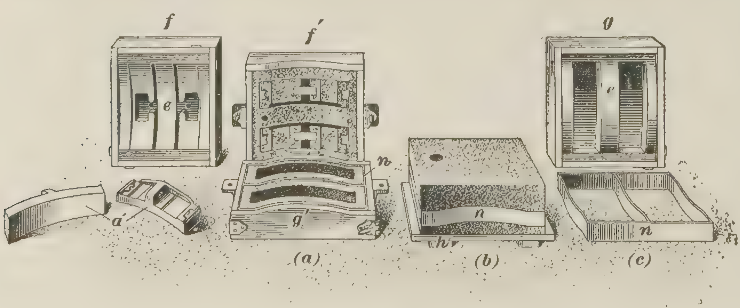


Fig. 16

mold cannot be packed uniformly with flat presser boards; formed presser boards are therefore used. The brake-shoe molds and formed presser boards are shown in Fig. 16 (*a*), (*b*), and (*c*). The presser board *f* for the cope, view (*a*), has approximately the shape of the joint surface of the cope *f*′.

Since the sand in the cope is made of nearly uniform thickness by this presser board, it is packed more uniformly than is possible with a flat board. The drag g' is pressed with the presser board g, view (c). The sand is left more uniform by this board than would be possible with a flat board.

These presser boards leave both the top and the bottom of the mold irregular in shape, and it is therefore necessary to level them off before the flask is removed. Both the cope and the drag may be leveled by adding enough loose sand to give a bottom board bearing all over.

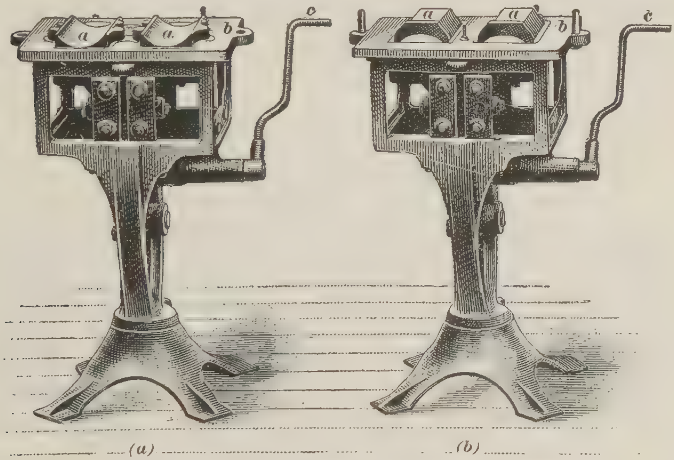


Fig. 17

The joint frame shown at n, views (b) and (c), is put into the cope and allowed to remain on the mold when the flask is removed. It holds the mold together and prevents the metal from running out on the joint. The completed mold is shown in (b), on a bottom board h ready to be poured.

32. The molding machines shown in Fig. 17 are used to draw the patterns through stripping plates. The patterns a are railway-car brasses. The stripping plates are shown at b. The machine shown in (a) is used to mold the drag and the one illustrated in (b) to mold the cope. The patterns are shown in the molding position, and the machines are ready to receive

the flasks. When the flasks have been filled and rammed, the patterns are drawn downwards through the stripping plate by turning the crank *c*.

33. Some machines are employed to draw the pattern by raising the cope off the pattern and by lifting the pattern out of the drag. In such a case, the pattern must be mounted in a vibrator frame, on the opposite sides of a match board, or a pattern plate must be used. The mold is made by placing the cope side of the match board down, with the pattern resting in a match; then the drag is put in position and filled with sand. A bottom board, which must be small enough to go inside the flask when the mold is pressed, is then put on, the half mold is turned over, and the match is replaced by

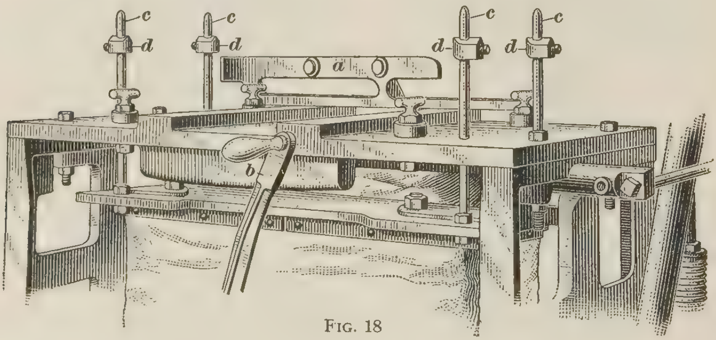


FIG. 18

the cope flask. After the cope is filled with sand, both the cope and the drag are pressed. The machine shown in Fig. 18 is then used to open the mold and draw the pattern. The mold is set on the machine in front of the stop *a*, which locates it in the proper position. Then, by moving the lever *b* to the right, the four pins shown at *c* are pushed up and their ends bear on lifting lugs that are fastened to the cope. The cope is then raised clear of the pattern and the collars *d* strike the edge of the match board, which is thus lifted from the drag. The match board is next withdrawn from between the cope and drag, and the cope is lowered into position on the drag. A vibrator may be attached to the match board to vibrate the pattern while it is being drawn.

34. Some molds contain parts in which the sand cannot be supported by the simple form of stripping plate shown in Figs. 15 and 17. Such parts may frequently be held on stools. A gear pattern that is fitted to a stripping plate machine is shown in Fig. 19. The stripping plate *a* is fastened to the frame of the molding machine, and the flask *b* rests directly on it. The edge of the stripping plate is made to fit the outline of the teeth on the gear, so that the sand between the teeth will be supported when the pattern is drawn. The stripping plate cannot, however, support the sand inside the gear. This sand rests on stools *c* that are fastened by the stool plate *d* to the frame of the machine. The pattern *e* is fastened to the pattern plate *f*, which is guided in a vertical direction by shoes *g* that slide on guides in the molding-machine frame. The pattern plate is raised and lowered by the lever *h* through the shaft *i*, the crank *j*, and the link *k*. The part of the pattern that extends above the stripping plate and stools is like a split pattern that is mounted on a match board. The extension of the pattern below the level of the stripping plate and stools serves only to support the pattern in the proper position.

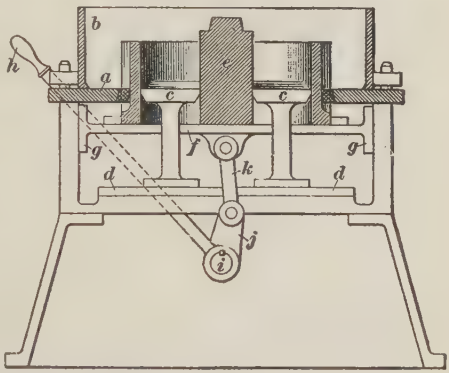


FIG. 19

35. The pattern shown in Fig. 20 is similar to the one shown in Fig. 19, but it is fitted to a different kind of a molding machine. The stripping plate *a* and the stool plate *b* are fastened to four rods *c*. These rods not only hold the stripping plate and the stool plate in the right position with respect to each other, but also act as guides, as will be explained. The pattern plate *d* rests on the frame of the molding machine, to which it remains fixed. When the cranks *e* are turned,

the stool plate b is lifted by the links f and the stripping plate is raised by the rods c. These rods fit holes in the frame of the molding machine and guide the stool and stripping plates so that they are moved perpendicularly. When the stripping and stool plates are raised, the flask, which rests on the stripping plate, is lifted off the pattern. The pattern remains stationary while the mold is being lifted by this machine, but the mold remains stationary while the pattern is being drawn by the machine shown in Fig. 19.

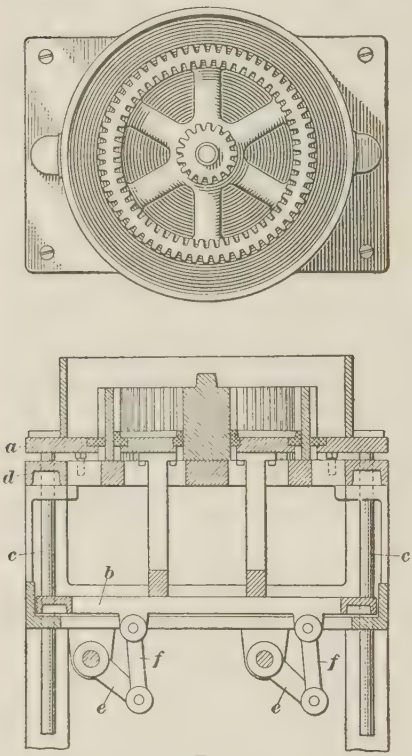


Fig. 20

36. The pattern-drawing machine shown in Fig. 21 is especially well suited to long, shallow patterns. The illustration shows a little more than half the length of the machine and most of the pattern plate a is cut away in the top view. When the machine is ready for a mold, the pattern plate a is raised until it is level with the top edge of the side piece b, on which the flask rests. The flask is then filled with sand and rammed and the pattern is drawn by lowering the pattern plate. In the machine shown, the pattern plate is lowered by means of an electric motor, but hand levers are used on some machines of this type.

The motor turns the shaft c, which is connected by bevel gears to the screw d. The turning of the screw d moves the nut e up or down, and the link f, which is pivoted to the nut e,

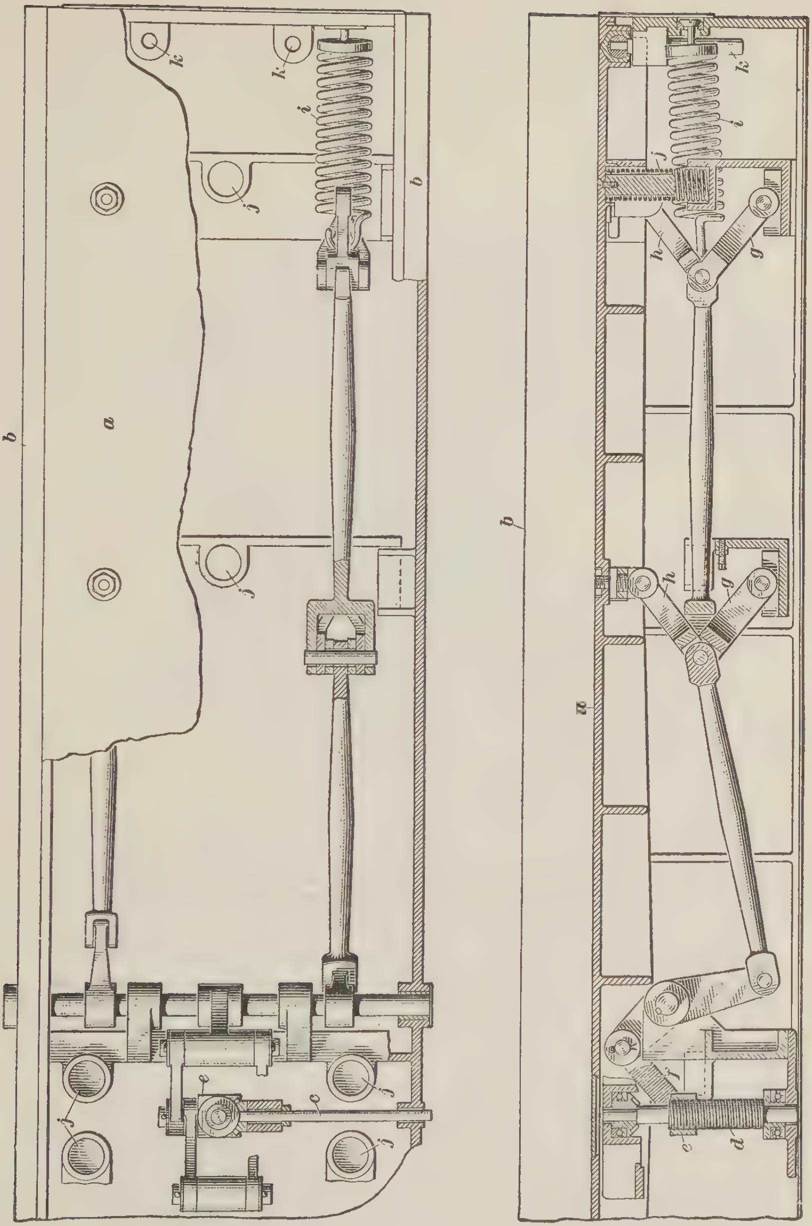


FIG. 21

operates the toggle links *g* and *h* through the crank and connecting-rod mechanism. When the pattern table is nearly at the lowest point in its motion, it tends to move more rapidly than when it is just starting to be lowered; it is therefore liable to strike the stops that limit its downward motion and thus jar some sand loose from the mold. In order to avoid this danger, two springs, one of which is shown at *i*, are placed at each end of the machine and other springs are placed under the table at *j*. The springs *j* take some of the weight of the pattern plate off the toggle links just before the stops are reached. The motion of the pattern plate is kept vertical by guide pins *k* that fit into holes in lugs on the frame.

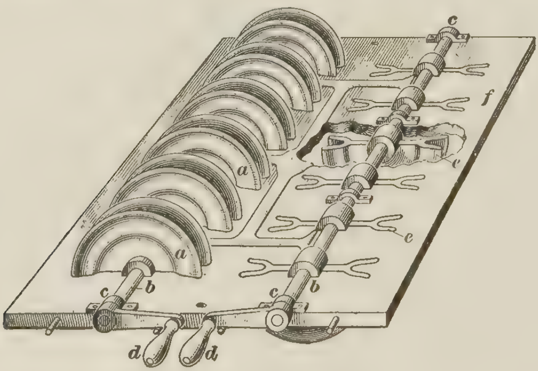


FIG. 22

37. Pattern Rolled Out.—Sometimes patterns that cannot be drawn in the usual way may be rolled out of the sand. Such a pattern is shown in Fig. 22. This is the pattern for a sheave wheel that could not be drawn from the sand on account of the undercutting of the sand at *e*. This pattern might be parted in a plane at right angles to the shaft; but it would then require a three-part flask; whereas, the present arrangement will be found to require only two parts.

Each pattern *a* is exactly half of the wheel that is to be molded and the patterns are mounted on the shafts *b*. The shafts and patterns are mounted on the stripping plate *f*, so that the diameters along which the patterns are parted will be even with the top of the plate, whether the pattern

is up or down. The patterns are drawn by turning the cranks *d* on the ends of the shafts. The print of the shaft *b* may be used as a core print; the prints of the bearings *c* may have to be filled if they are so near the castings that the metal will break through into them.

38. The machine frame shown in Fig. 23 may be arranged as a combination match-plate and stripping-plate pattern. The pattern as a whole may be made like a split pattern, each half of which is mounted on a match board. The prongs *a*, *b*, and *c* cannot, however, be drawn in this way, and they are therefore made to draw through a stripping plate. The arrangement of the pattern is shown in Fig. 24, in which letters referring to corresponding parts are the same as in Fig. 23. Fig. 24 (*a*) shows a plan of the pattern and match

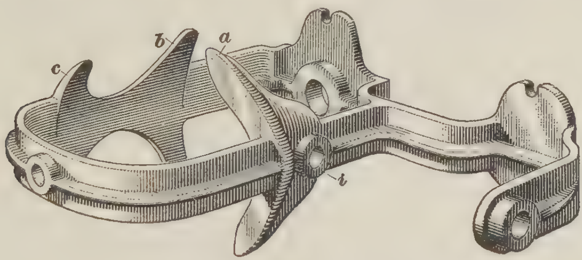


Fig. 23

board, and (*b*) an elevation. The prongs *a*, *b*, and *c* are made in two parts that are separate from the main pattern and are hinged below the match board at *d*. The pattern of which prong *a* is a part is fastened to the shaft *e*, and the pattern for prongs *b* and *c* is a part of the hollow shaft *f*. There are two cranks *g* and *h* at one side of the match board by means of which the patterns of the prongs *a*, *b*, and *c* are drawn from the sand. When crank *g*, which is fastened to shaft *e*, is moved downwards, prong *a* is drawn from the sand, and in a like manner prongs *b* and *c* are drawn by crank *h*, which is fastened to shaft *f*. The hub *i* and the core prints *j* cannot be drawn through the stripping plate with the prong *a*: therefore, they are fastened to the surface of the match board.

39. Gear-Molding Machines.—Gear-molding machines are used to make the molds for the teeth of gears. One type of such machine suitable for gears of the largest diameters is shown in Fig. 25. The base of the machine rests on the bottom of the mold and supports a vertical column *a* in the

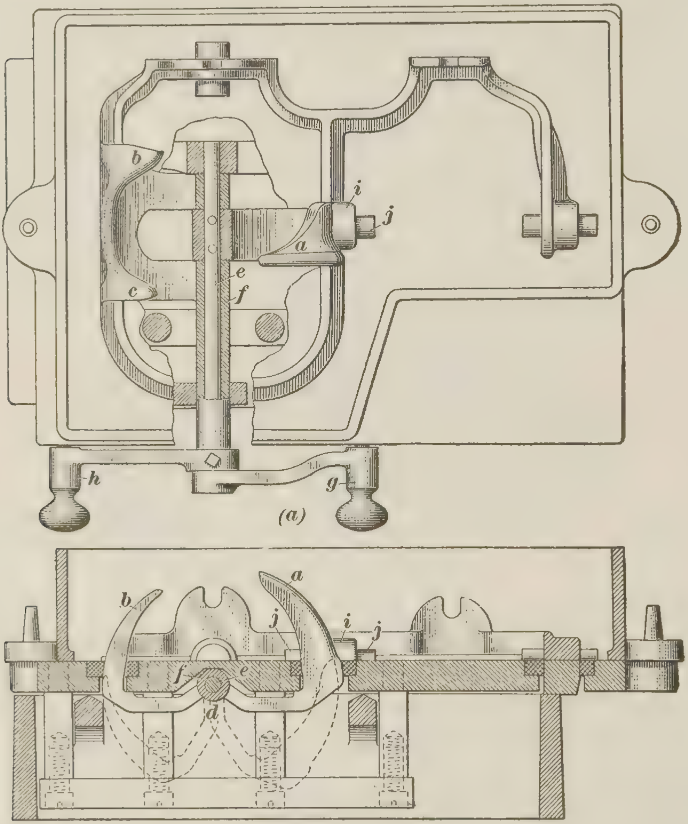


FIG. 24

center. This column carries an arm *b*, which revolves on the column *a*; it also has a horizontal movement and adjustment by means of the wheel *c* and a rack, and carries an indexing mechanism at one end. A vertically adjustable arm *d* carries at its lower end a pattern *e* for one or two teeth of

the gear. The pattern is lowered to the required position for making the mold, and the length of the revolving arm *b* is adjusted to give the diameter of the gear desired. The sand is rammed against the face of the pattern, as shown at *f*. The pattern is then withdrawn vertically from the mold, and the arm *b* supporting the pattern is rotated forwards by means of the indexing mechanism the exact distance of another tooth or set of teeth; the pattern is next lowered, and the ramming process is repeated. The indexing mechanism con-

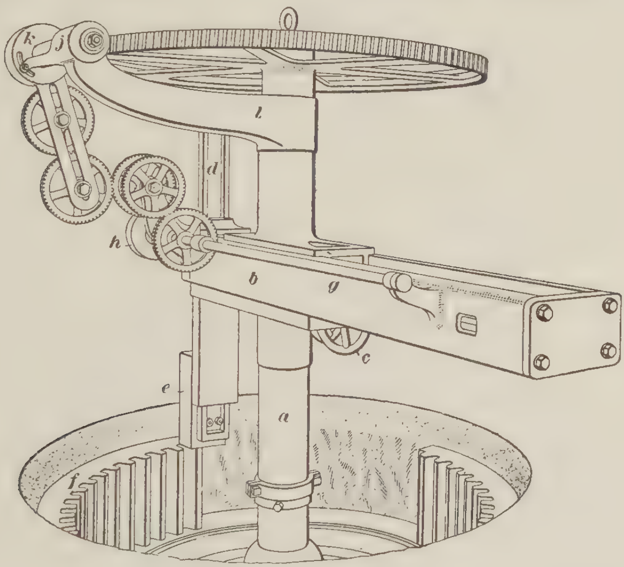


Fig. 25

sists of a train of gears between the shaft *g*, which is operated by a crank revolving on the face of the index plate *h*, and the large stationary gear attached to the top of the column *a*. A worm in the case *j* meshes with the large gear and carries a gear on the end of its shaft in the case *k*, which receives motion from the train of gears extending to the shaft *g*. The arrangement is such that by revolving the shaft *g* by means of the crank, the arms *l* and *b*, which are connected together, are revolved on the column *a*. The index in each case must

be set to divide the circumference of the gear into the number of equal parts to correspond with the number of settings required. The molds for the arms, ribs, and hubs of the gears are made with the aid of special patterns and placed in the mold after the machine has been removed.

The mold for the inside of the rim, the spokes, and the hub of this wheel may be made of dry-sand cores. When these cores have been put in position, the spaces between and around them are filled with green sand, the top edge of the rim mold is closed with a cover core made of dry sand, and the top of the mold is leveled off with green sand. The cope is then put in place, filled with sand, and rammed as much as may be necessary to maintain the shapes of the sprue and risers. The object of the cope is to hold the cover cores down and to give the required height of sprue and risers.

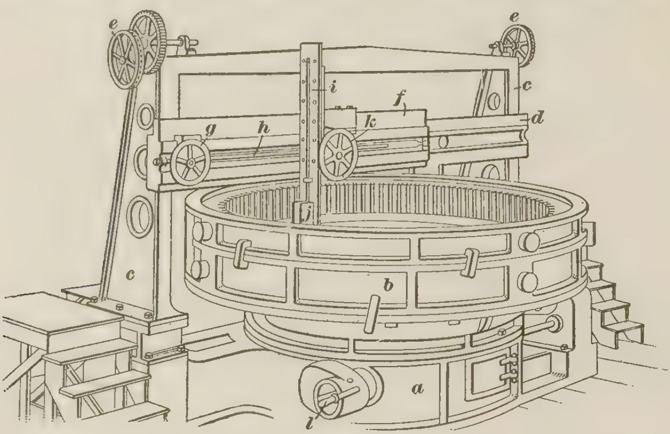


Fig. 26

40. Another form of gear-molding machine is shown in Fig. 26. This machine consists of a base *a* having a rotating table on which the flask *b* rests. The frame *c* supports a cross-rail *d*, which is arranged so that it may be raised or lowered by the wheels and gearing shown at *e*. The head *f* may be moved across the machine on the cross-rail by the wheel *g*, which turns the feed-rod *h*. The head carries the pattern support *i*, to which the pattern block *j* is fastened.

This pattern block molds only one tooth and one space at a setting. Patterns that mold more than one tooth and one space may be used when the number of molds warrants the expense of the larger pattern. When the sand has been packed behind the pattern, the pattern is drawn either by lifting it vertically or by moving it radially toward the center of the mold. When the pattern support i stands vertically, the pattern may be lifted out of the mold by turning the wheel k, and the pattern is drawn radially by turning the cross-feed wheel g.

41. The machine shown in Fig. 26 may also be arranged to mold bevel gears by tilting the pattern support i to the proper angle and replacing the spur-gear pattern with one suitable for bevel gears.

When the teeth are all molded, the flask that is on the machine is lifted off and set on the molding floor. The cores for the spokes, hub, and rim are then set, and the mold is completed in the manner already explained.

When molding the teeth of the gear, the mold must be turned each time after molding the teeth on the pattern. The turning of the mold is called *indexing*. The mold is indexed by turning the handle l. When the pattern consists of one tooth and one space, the mold must be indexed, or moved ahead, a distance equal to the pitch of the gear; when the pattern contains more than one tooth, the mold must be indexed as many teeth as there are teeth in the pattern for each setting. The longer the pattern, the fewer the number of settings that will be required to complete the mold for the teeth. The less the number of settings that are required, the quicker the molder will be able to make the mold, but the greater will be the cost of the pattern.

42. Special Pattern-Drawing Machine.—A pattern-drawing machine in which the flask is shaped to conform somewhat to the shape of the casting is shown without pattern, stripping plate, or flask in Fig. 27. This form of pattern-drawing machine is shown here to illustrate the way in which adaptations to meet special conditions may be made. In

operation, it is a regular stripping-plate machine, the stripping plate being fastened to the frame *a* and the pattern plate to the frame *b*, which moves vertically in the guides, one of which is shown at *c*. The frame *b* is shown in the upper, or molding, position. When the machine is in use, the pattern is drawn by turning the lever *d* to the left. This lever is attached to the shaft *e*, which carries two cranks, one of which is shown at *f*. The crank is attached to two links *g* and *h*. The link *g* is one of four that support the pattern frame. The two links corresponding to *g* that support the farther end

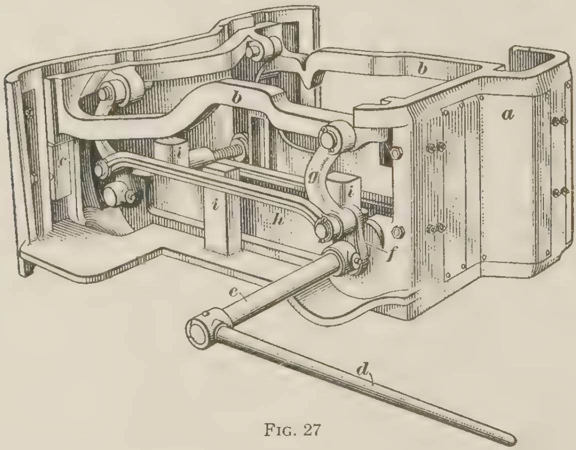


FIG. 27

of the pattern frame are connected to cranks on a shaft parallel to *e*. In order that the pattern may be drawn squarely from the mold, the shafts are connected by two links, one of which is shown at *h*. When the pattern has been drawn, the frame *b* is down resting on stops *i*.

This type of machine is sometimes fitted with trunnions by which the flask and molding machine may be turned over by a crane after they have been clamped together. The molding machine is thus placed on top of the mold, so that the pattern is drawn from the top side of the joint.

COMBINATION MACHINES

43. Hand Squeezer and Pattern Drawing Machines. A machine that is used to mold both the cope and the drag at the same time is shown in Fig. 28. The patterns are fastened to the presser head, the one for the drag being at *a* and the one for the cope at *b*. The molding operation is as follows: The cope and drag flasks are placed over the respective patterns and filled with sand; a presser board is set on top of each and clamped fast. The molds are then rolled over by

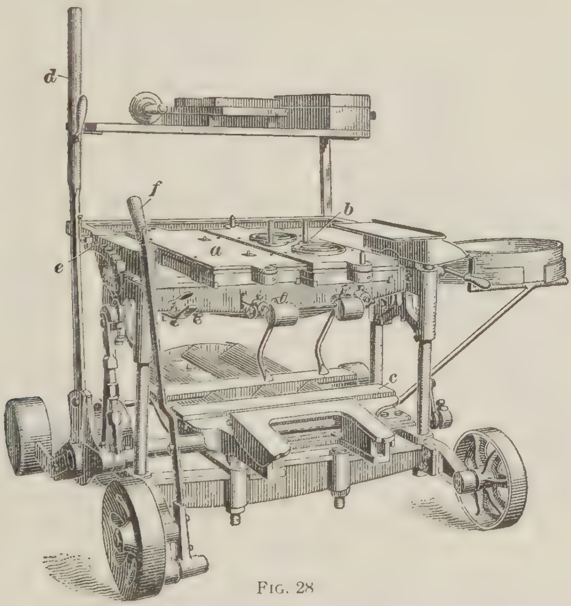


FIG. 28

hand so that the presser boards are over the presser table *c*; then the molds are squeezed by drawing to the front and pressing down on the long lever *d*. This movement raises the presser table against the molds. When the molds have been compressed a certain amount, the clamps holding the presser boards in place are automatically released and they spring back clear of the presser boards. The pattern is then drawn by slowly returning the presser handle *d* to the vertical

position. Returning the presser handle lowers the table *c*, on which the molds are now resting, and allows them to drop away from the pattern and thus draw the pattern from the sand. In order that a clean draft may be obtained, the pattern is vibrated by rapping a vibrating pin, not shown, on the back of the table to which the patterns are fastened. When the patterns are drawn, the lever *d* is locked by a dog that engages the toothed segment *e*, while the table *c* on which the flasks are now standing is drawn forwards by pulling on the lever *f*. The molds are thus brought out when they are easily reached, and the cope may be turned over and placed on the drag before the mold is removed from the machine.

44. The machine just described may be arranged to operate by compressed air by connecting the piston from an

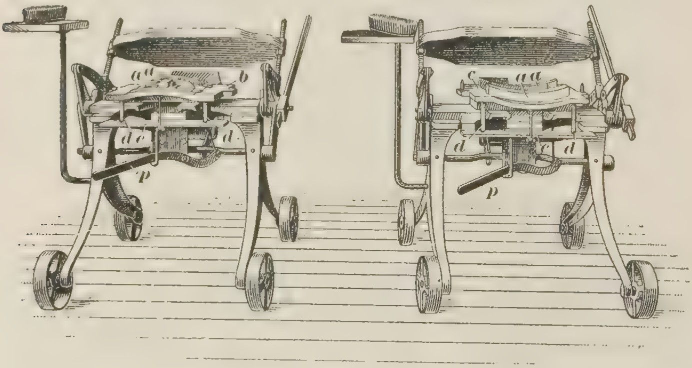


Fig. 29

air cylinder to the lever *d* or the casting to which it is fastened and attaching a vibrator to the pattern plate. When the machine is arranged in this way, larger molds can be handled than would be possible on a hand-operated machine. It is of course not possible to squeeze as large molds when two are made as when only one is made at a time, but when the molds are not too large, one operator can make more molds in this way than with a machine that makes only one mold at a time, though he will not produce them twice as fast.

45. In Fig. 29 are shown molding machines that are fitted with the brake-shoe pattern and stripping plate from Fig. 15. The machine on the left is fitted with the cope pattern, and that on the right, with the drag pattern. The presser part of this machine is the same as the machine shown in Fig. 2. There is, however, a pattern-drawing arrangement added below the presser table. The patterns *a* rest directly on the presser table, as do also the stripping plates *b* and *c* while the mold is being pressed. The pattern is drawn by raising the lift

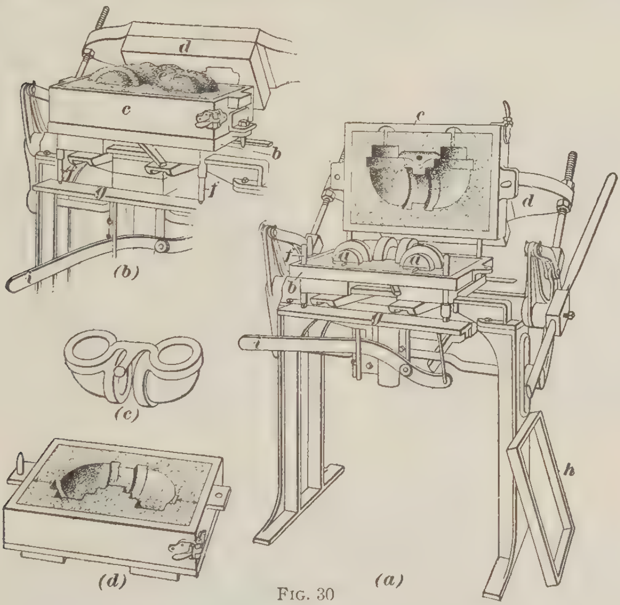


Fig. 30

table *e* so that it strikes the legs *d* of the stripping plate. The stripping plate and the mold that rests on it are lifted off the pattern. The lift table is raised by lifting on the lever *p*, which may be fastened with a latch when the pattern has been drawn and the mold thus held off the pattern.

46. A squeezer machine arranged to be used with a pattern that needs no stripping plate is shown in Fig. 30. The pattern *a*, view (*a*), is an ordinary split pattern in which the cope and drag molds are exactly alike. The patterns must therefore

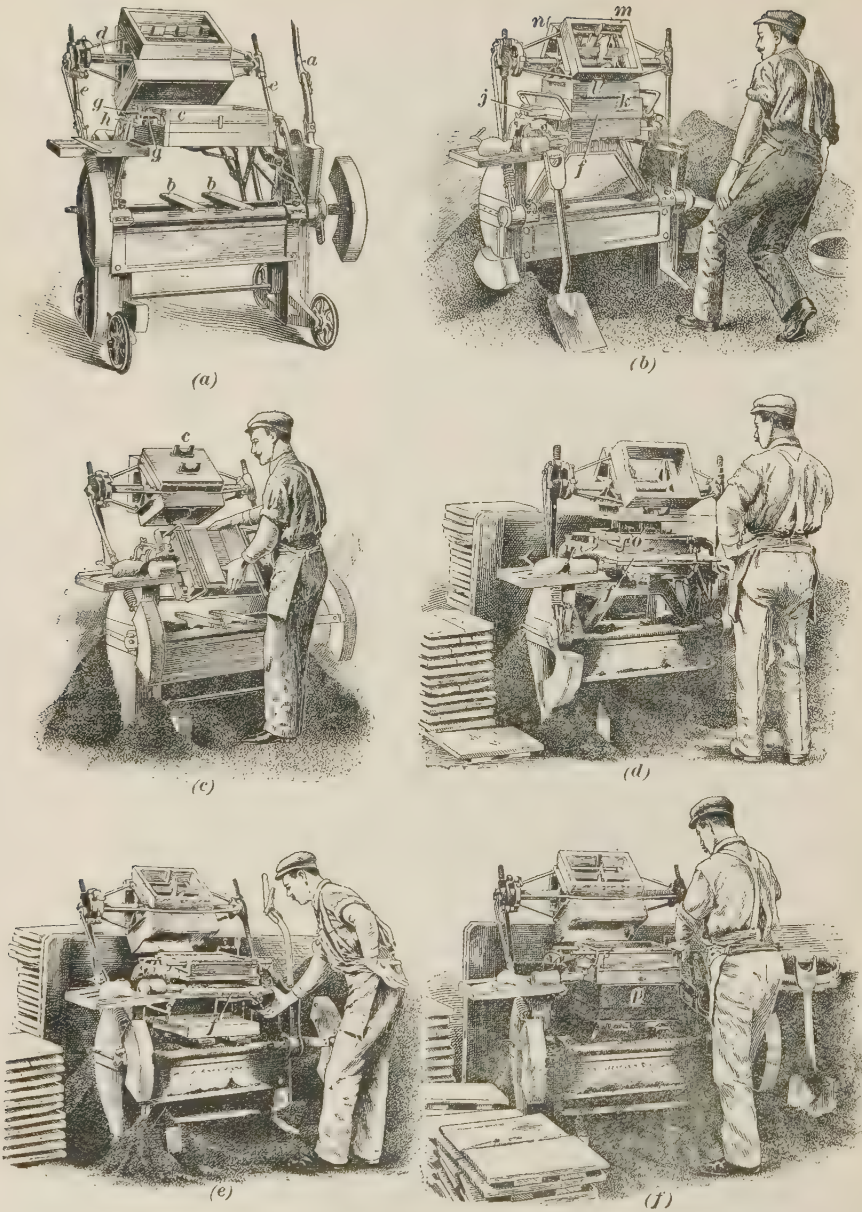


FIG. 31

be placed on the match board *b* so that the two halves of the mold will fit together properly. The cope flask *c* is shown turned back against the presser head *d*. This flask is lifted off the pattern by the pins *f*, which pass through holes in the corners of the match board. These pins are raised by the lift table *g*, on which they rest, and the lever *i*.

In order that the sand may be packed uniformly in all parts of the mold, the presser head is cupped out to approximately the form of the pattern and the sand before pressing is heaped on the back of the flask. The sand frame *h* is put on the back of the mold so that enough sand may be available to enable the mold to be pressed to the required density. The formed presser head leaves the back of the mold irregular in shape, and the excess sand must therefore be removed with a strike bar. The effect of the formed presser head is shown in (*b*); view (*c*) illustrates the casting with the gate and sprue attached, and (*d*), the drag mold ready for the cope.

47. A hand-operated molding machine used to perform several operations is shown in Fig. 31. This machine peens both the drag and the cope, squeezes the mold, draws the pattern, and closes the mold. The presser head of this machine

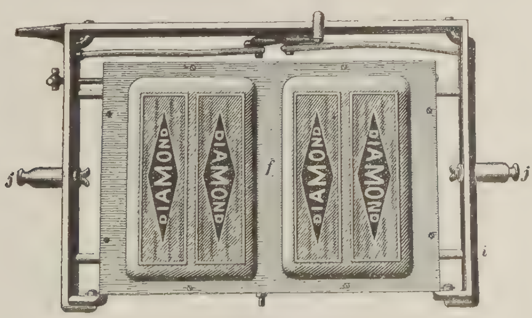


FIG. 32

is a turret composed of three parts *l*, *m*, and *n*, view (*b*), and the pattern is placed on a match board. The match board is then clamped in the frame *i*, Fig. 32, which is supported in the machine on the trunnions *j*, Figs. 31 (*b*) and 32.

48. The operation of the machine just described is as follows: The match board is turned with the drag side up and the drag flask *c*, Fig. 31 (*a*), is put in place and filled with sand. The sand is then packed around the outside of the mold by the drag peening frame *l*, view (*b*), after which the sand on the top of the flask is smoothed off and a bottom board is clamped in position. While peening the drag *k*, the match board *f* is supported by a cope flask that is put between it and the presser table *b*, in view (*a*). When the drag has been peened, the mold is turned over, as shown in (*c*). The cope is then filled with sand and peened with the frame *m*, view (*b*), which is brought into position by turning the turret on the spindle *d*, view (*a*). The surplus sand is then struck off, and the cope and drag are squeezed. To squeeze the mold, the presser head *n*, view (*b*), is turned into position and the hand lever *a*, in view (*a*), is pushed down. This movement pushes the presser head into the cope and the bottom board into the drag. The sprue cutters *o*, view (*d*), may be attached to the presser head so that the sprues will be cut when the mold is squeezed.

The cope and the drag are then separated, as shown in (*e*), thus drawing the pattern, and the pattern plate is swung to the rear from between the flasks, after which the mold is closed and the flask is removed, as shown in (*f*). The flask is made tapering, growing smaller toward the top of the cope, and a movable internal rib holds the sand in the flask until it is to be removed, when the rib is withdrawn flush with the inside of the flask. The two parts of the flask are then locked together and lifted off the mold, which is shown at *p* on the bottom board.

49. Power Squeezer, Pattern Drawing Machines. A molding machine that riddles the sand, rolls the flask over, squeezes both cope and drag, draws the pattern, and closes the mold is shown in Fig. 33. This machine is intended for the making of small molds in which match boards can be used.

The match board *a* is in position for the drag flask. When the flask has been placed on the match board, sand is put

in the riddle *b*, which is then swung forwards over the flask. This movement automatically turns air on to a vibrator that shakes the riddle and riddles sand into the flask. The bottom board is then put on and clamped fast, and the flask is rolled over by hand. The match board is mounted in a frame that is pivoted at the corner *c*, where there is a hinge that permits turning the mold over and swinging horizontally, as will be explained.

When the drag has been filled and turned, the cope is put on and filled in the same manner; then the mold is swung

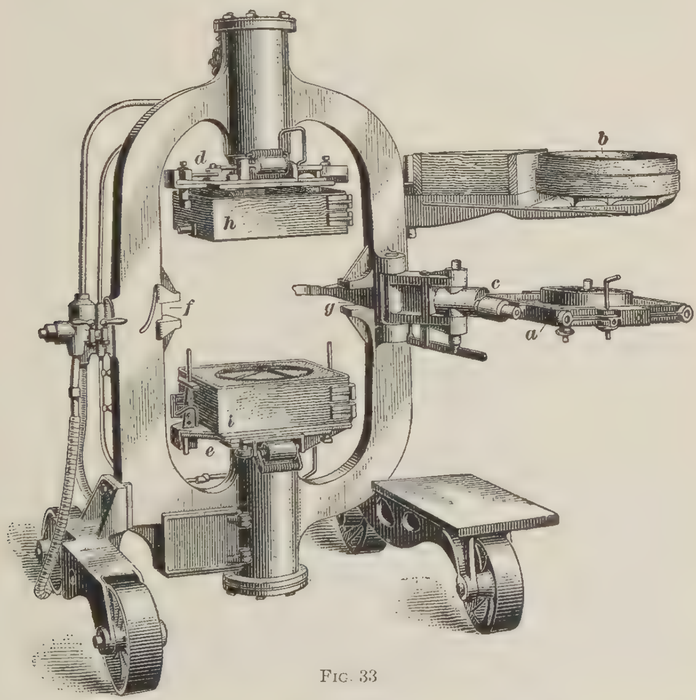


Fig. 33

in between the squeezer heads *d* and *e*. Projections on opposite edges of the match board fit into sockets *f* and *g* on the frame and hold the match board while the mold is being squeezed.

While the presser heads are in contact with the mold, the presser head *d* is clamped to the cope and the head *e* to the

drag; thus, when the presser heads are drawn, the pattern is drawn from both the cope and the drag side of the mold, as shown at *h* and *i*. The match board is then swung back into the starting position, and the mold is closed when the cores have been set.

Sometimes this machine is provided with a track back of the presser head *e*, so that the completed mold may be pushed

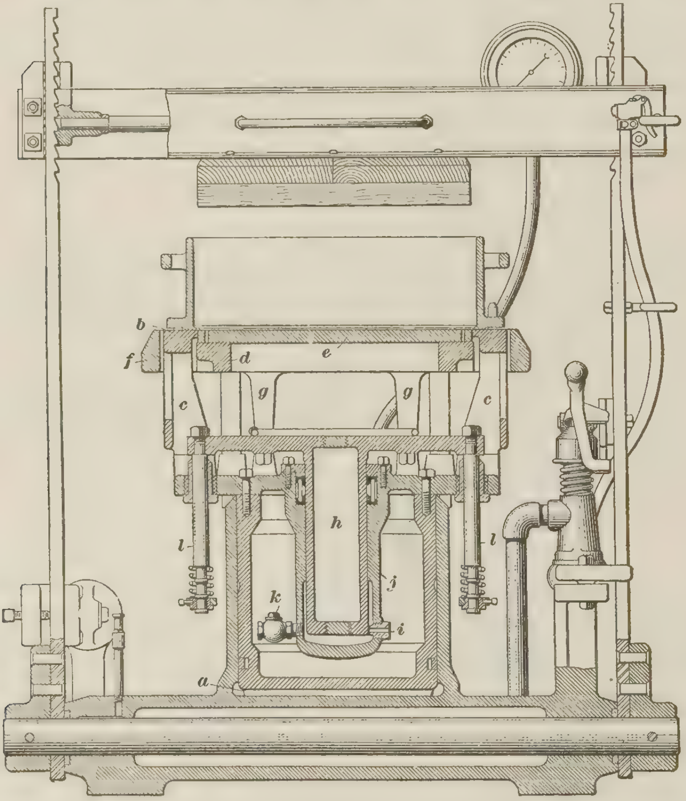


FIG. 34

out on it, where it is in a more convenient position to be carried away.

50. A molding machine that squeezes the mold and draws the pattern by power is shown in Fig. 34. The squeezer

cylinder *a* lifts the mold against the squeezer head in the usual manner. The pattern-drawing cylinder is placed in the center of the squeezer plunger and lifts the mold off the pattern. The flask rests on the frame *b*, which is supported on the top of the squeezer plunger by legs *c*. The frame *d*, on which the pattern board *e* rests, is also supported on the top of the squeezer plunger. The frame *f* is supported by the legs *g* on top of the pattern-drawing plunger *h*.

After the mold is squeezed, the pattern is drawn in the following manner: The squeezer plunger is filled with oil, which is forced by the pressure of air admitted on top of it through the nipple *i* into the pattern-drawing cylinder *j*, thus raising the plunger *h* and the frame *f*, which process lifts the mold off the pattern.

The end of the nipple *i* is very near the pattern-drawing plunger when it is down, so that when pressure is first applied to the oil, the flow into the pattern-drawing cylinder is slow until the plunger *h* has risen far enough to uncover the end of the nipple. The mold is therefore lifted slowly off the pattern at first, but after it is started the motion is more rapid. When the finished mold has been removed from the machine, the frame *f* is returned to the molding position by releasing the air pressure on the oil. The oil is thus allowed to flow from the pattern-drawing cylinder through the nipple *i* and the check-valve *k*, so the motion is rapid and little time is lost. The rods *l* limit the motion of the pattern-drawing plunger and keep it from being blown out of its cylinder.

51. Other molding machines that squeeze the mold and draw the pattern have two pattern-drawing cylinders placed at diagonally opposite corners of the frame that lifts the mold. The drawing of the pattern is begun by hand and the mold is then lifted off by power.

52. Hand-Operated, Turn-Over Molding Machine. A hand-operated machine that turns the mold over after it has been rammed and draws the pattern is shown in Fig. 35. The pattern *a* on the pattern board *b* is a grate bar that is molded in the drag, the cope, with the exception of the sprue,

being perfectly flat. The pattern board is in position for the flask, which is filled and rammed by hand. The bottom board is then bedded and clamped to the flask. The pattern board is fastened to the frame *c*, which is hinged at *d* so that the flask is turned by hand to the position *e*. The turning of the flask is made somewhat easier than it would otherwise be by the spring *f*, which pulls on the arm *g*.

The pattern is drawn, when the clamps that hold the mold to the pattern board have been removed, by drawing out and pressing down on the lever *h*. This movement of the lever *h* raises the pattern frame *c* straight up, thus drawing the pattern from the sand. The motion of the frame *c* is

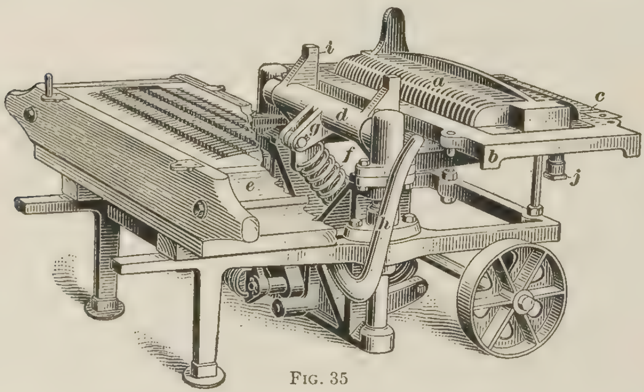


FIG. 35

guided by brackets *i* that slide on the side of the flask, and the pattern is rapped by the pneumatic vibrator *j*. When the pattern has been drawn, the pattern board is turned back by hand to the position shown in the illustration, and the flask is left on the other side of the machine ready to be removed and to receive the cope.

53. Power, Turn-Over Molding Machine.—The molding machine shown in Fig. 36 performs the same operations as the one just described, but it is operated by air instead of by hand power. The pattern board *a* and the pattern *b* are turned over until they rest on the supports *c* and *d*, in which position the pattern is ready for the flask. The flask is

filled and rammed by hand, and the bottom board is bedded to the flask and clamped fast, as before. The flask is, however, turned over by the power of an air cylinder. When air is admitted to the turn-over cylinder, the pattern board and flask are turned about hinges at *e*, and the flask is put in the position shown at *h* on the receiving table.

The pattern is drawn by admitting air to two cylinders that are smaller than the turn-over cylinder. One of the pattern-drawing cylinders is shown at *f*. The pattern is then lifted vertically out of the sand, as shown in Fig. 36, while it is being rapped by the vibrator *g*.

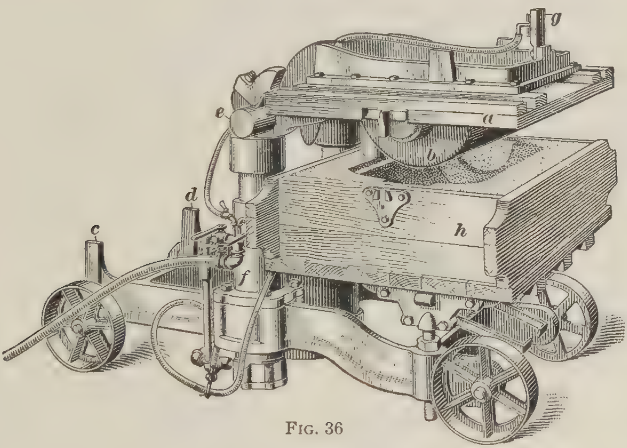


FIG. 36

54. Jar-Ramming, Roll-Over Molding Machine.—A further development of the type of molding machine just described is shown in Fig. 37. In this machine, the mold is jarred and rolled over, and the pattern is drawn by power. In order that the jarring action may not be interfered with by the roll-over mechanism, the roll-over frame is not fastened to the pattern board while the mold is being rammed. The mold is jarred in the same manner as in a plain jarring machine, after which the roll-over frame is brought into contact with the pattern board, the bottom board is put on the flask, and the flask, bottom board, and roll-over frame are clamped together. The mold *a* is then rolled over on to the receiving

table *b* by admitting air to the cylinder *c*. The receiving table *b* may be adjusted by means of the hand wheel *d* to the proper height to receive the mold.

The pattern is drawn by admitting air slowly to the cylinder *c*. The side rods *e* will not begin to turn the mold or the pattern board in either direction until they have been lifted vertically through a distance equal to the maximum draft.

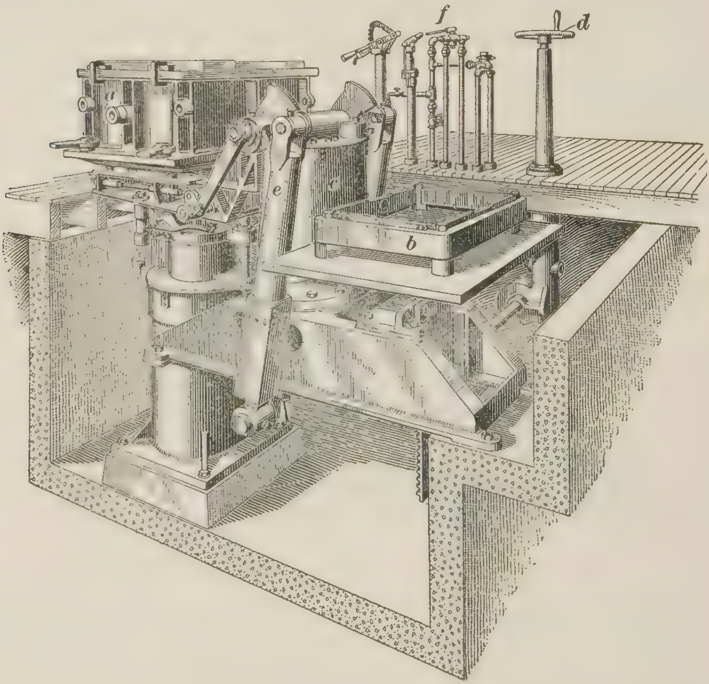


Fig. 37

This machine is built in a pit, so that most of it is below the floor. In the illustration, the floor and one side of the pit are left out, so as to show the molding machine more clearly. In order that the machine may be operated conveniently, the controlling mechanism and the valves are placed near together at *f*.

55. Gravity Molding Machine.—The side view of a molding machine that performs more of the operations required

in the making of a mold than any of the machines described thus far is shown in Fig. 38. It riddles the sand, fills and rams the flask, strikes off the excess sand, turns the flask over, and draws the pattern. The pattern board and flask are first clamped to the cradle *a*, which is supported by four rods *b* and a mechanism that will be explained presently. These rods are arranged so that the cradle may be swung back and forth, but will always be held in proper position for ramming.

56. The sand is riddled, put into the mold, and rammed in the following manner: It is first shoveled into an opening in the floor so as to fall on a riddle *c*, through which it passes to a hopper below the floor. From this hopper the sand flows into the elevator boot *d*, and then it is taken up in the shallow buckets *e* of the conveyer. The quantity of sand that flows to the elevator boot is regulated by raising or lowering the gate *f* over the opening in the bottom of the sand hopper by means of the lever *g*.

While the cradle *a* with the flask is swinging back and forth, the elevator is carrying sand to a point near the top of the machine, from which point it is dropped into the flask in the form of compressed bodies; the hardness of these bodies, together with the height through which they are dropped, determines the hardness of the mold. The hardness of the sand bodies depends on the hardness with which the sand is packed into the elevator buckets by the sand packer *h*.

When the flask has been filled with sand, and while the cradle is still swinging, the strike bar *i* is swung down to scrape off the surplus sand. The strike bar is raised and lowered by turning the hand wheel *j*.

The cradle is suspended from a carriage *k* that runs on a track passing through the machine from side to side. When the flask has been rammed and the excess sand struck off, it is run out to one side of the machine and the cradle and mold are turned over and set down. The cradle is pivoted so that the mold may be turned over and the rods *b* are jointed, one part telescoping within the other, to permit the cradle

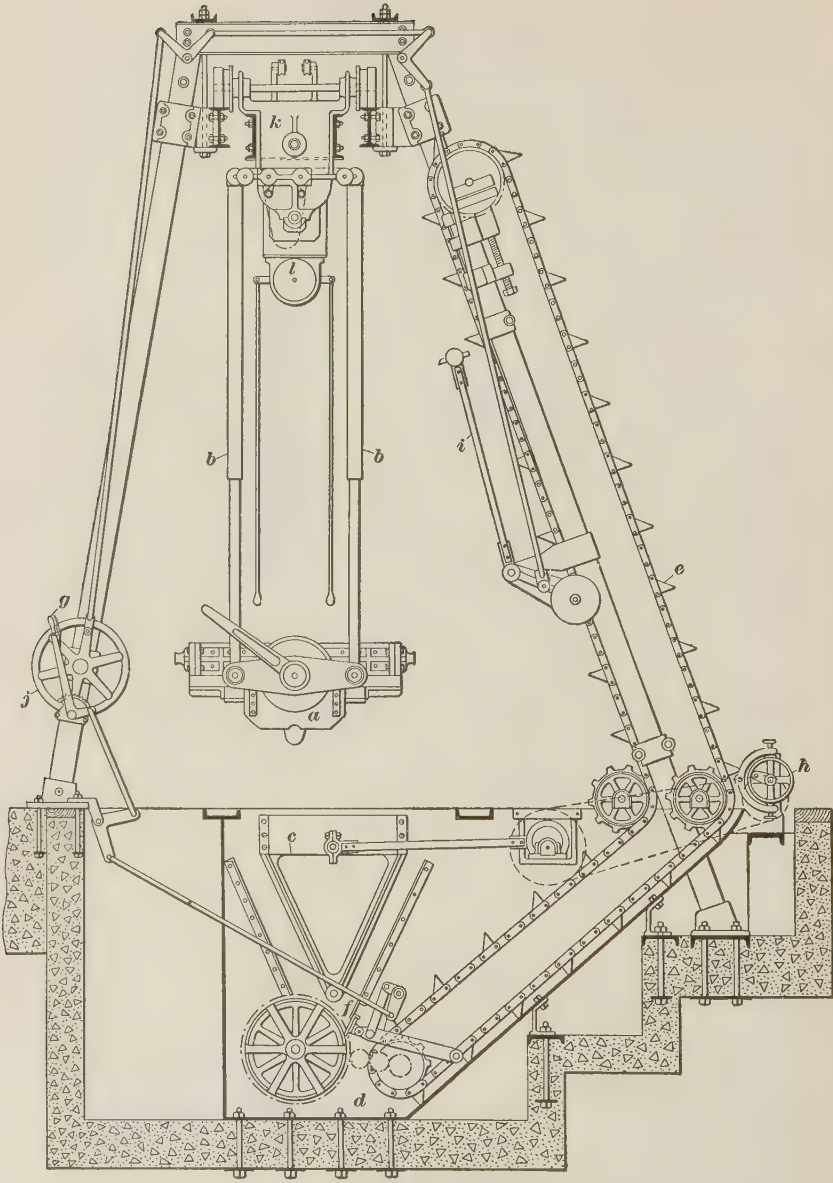


Fig. 38

to be raised and lowered, which operations are performed by means of an electric hoist *l*. The clamps that hold the mold on the cradle are then released and the cradle raised, thus drawing the pattern. The cradle is next turned over, another flask is clamped in position, and the cradle is ready to be run back into the machine to fill and ram another mold.

While the first carriage is out at one side of the machine, where the mold is turned over and the pattern drawn, another carriage is run into the machine from the other side and another mold is filled and rammed. Copes may be molded on one carriage and drags on the other, and the molds that leave the molding machine may be carried to the casting floor and closed by means of a traveling crane.

MOLDING-MACHINE PATTERNS

57. Pattern in Vibrator Frame.—Small patterns, especially when they have irregular partings, can frequently be mounted in a vibrator frame, as shown in Fig. 6. When so mounted, the cope side of the pattern must rest in a hard match of some kind while the drag is being rammed. The shape of the match, then, determines the shape of the parting surface. When ramming the drag, care must be exercised to have the pattern rest firmly in the match; otherwise, it may be seriously distorted or broken.

58. Pattern-Board Mounting.—Molds that are to be made on a molding machine are usually required in considerable numbers; therefore, the mounting of the pattern should be done more carefully than would be necessary when only a small number of molds are to be made. Pattern boards may be constructed either of wood or of metal. Wooden pattern boards should be strongly made to prevent warping and they should be boiled in paraffin or otherwise treated to keep them from absorbing moisture. Metal pattern boards may be made of saw plate, aluminum, or brass. The metal should be flat and smooth on the side to which the pattern is to be attached.

59. A pattern mounted on a wooden pattern board is shown in Fig. 39. It is part of the pattern for the frame of a grinding machine that is to be rammed on a jarring machine. There are six cleats *a* on the back of the board, and they are placed so as to support the board under the heaviest parts of the pattern. When the mold is to be jar-rammed, especial care should be taken that the cleats be placed so as to support the heavy parts of the pattern and thus avoid any danger of springing. If the pattern board is not sufficiently supported by cleats, it might spring and thus distort the pattern. This springing of the pattern and the pattern board would produce one or more of the following troubles: (1) Loosen the joints in the pattern; (2) loosen the joint between the pattern and the board; (3) destroy the pattern by loosening of the joints; (4) reduce the ramming effect of the jolt; (5) loosen the sand by recoil when the board springs back.

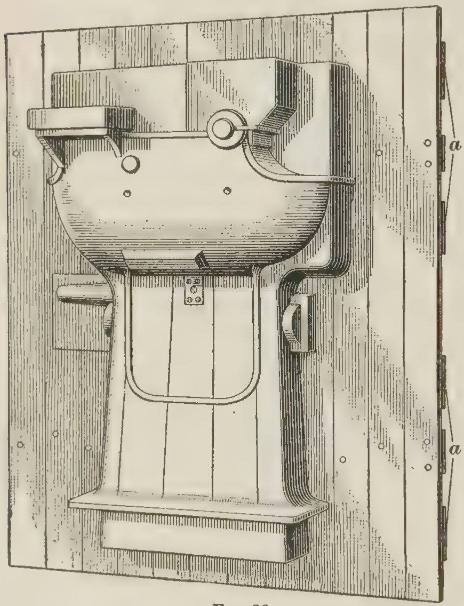


FIG. 39

The pattern must be fastened securely to the pattern board, so that it will not become displaced while in use and thus cause the cope and the drag molds to mismatch.

60. When the two parts of a split pattern are alike, both cope and drag may be molded with a half pattern, provided it is correctly placed on a pattern board that has sockets to fit the pins on the drag flask. The drag may be molded in the usual way. In order to mold the cope, however, the

pattern board must be provided with pins, or it may be set on a drag flask.

Consider, for example, the cylindrical pattern with one spherical and one flat end shown in Fig. 40 (a). If the pattern

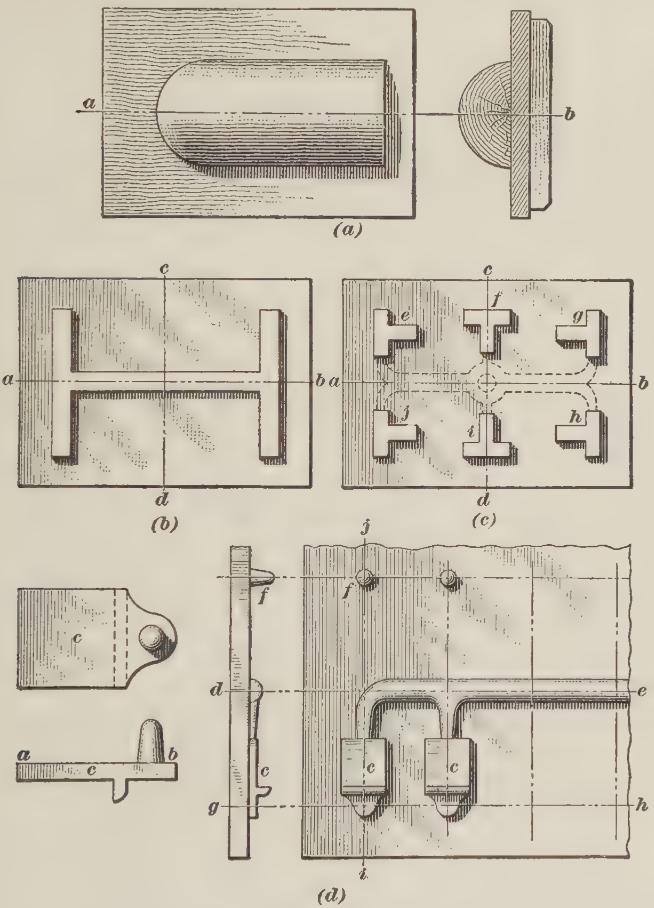


FIG. 40

is placed on the pattern board so that the center line $a\,b$ of the board is also the center line of the pattern, no attention need be given to the position of the pattern along this line, except to provide enough sand at the ends to keep the metal

from breaking out. Both cope and drag may be molded with a pattern mounted in this way. When placing the cope on the drag, it is only necessary to see that the round end of the cope mold matches the round end of the drag mold.

61. With a pattern like that shown in Fig. 40 (*b*), in which the two ends are alike, the pattern must be placed on the center line *a b*, as before; but it must also be placed so that the center line *c d* is midway between the end portions of the pattern. In order to facilitate the placing of such patterns as these, patternmakers are sometimes required to mark center lines corresponding to *a b* and *c d* on all patterns that are not permanently mounted, and pattern boards to which patterns are not permanently attached are similarly marked.

62. Several small patterns can frequently be placed in one flask. When the cope and drag sides are alike, the patterns may be placed on a pattern board in the manner shown in Fig. 40 (*c*). Such patterns must be so placed that the drag mold may be turned either end for end or sidewise and still permit the cope to match. If the drag is turned end for end, the cope mold of *e* will match the drag mold of *g*, etc., but if the drag is turned over sidewise, the cope molds of *e*, *f*, and *g* will match the drag molds of *j*, *i*, and *h*, respectively. Patterns *e*, *f*, and *g* must therefore be at the same distance from the center line *a b* of the pattern board as patterns *j*, *i*, and *h*, respectively, and patterns *e* and *j* must be at the same distance from the center line *c d* as patterns *g* and *h*. Patterns *f* and *i* are centered on the line *c d*. When the patterns are arranged in this way, they must be gated, as shown by the dotted lines.

63. The pattern for the flask pin shown at the left of Fig. 40 (*d*) may be arranged on a pattern board so that one pattern board may be used for both cope and drag. The pattern is parted on the surface *a b*, one part of the pattern being placed at one side of the center of the pattern board and the other part on the other side. The part *c* of the

casting is placed with the square end toward the center line, so that the gate will be more easily cut off. The pin *f* must be located as far from the center line *d e* as the center line *g h* is on the other side of it, and the pin must be placed on the line *i j*. Only one side of this pattern board is gated in this case. Drag molds made on a pattern board of this kind must be turned so that the center line *d e* does not change ends, as the cope molds of the parts *c* must come over a pin *f* when the mold is closed. A complete mold of this kind will have a set of castings on each side of the runner; the castings on one side will have the pin in the cope, while on the other side the pin will be in the drag.

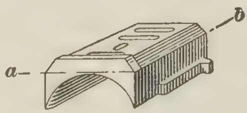
64. Match-Plate Mounting.—The nature of some castings is such that the densest metal obtainable must be on one side, whereas the density of the metal on the other side is of little importance. In a case of this kind, the side that must have the densest metal is molded in the drag and the other side is cast in the cope. The car brasses shown on the molding machines in Fig. 17 serve to illustrate this kind of casting. The bearing surface of the brass must be as dense as possible, to resist wear, and that side of the casting is therefore placed in the drag. A pattern for such a casting cannot be mounted on a pattern board in the manner shown in Fig. 40 (*c*) and (*d*); but it can be mounted on a match plate in the following manner: Fig. 41 (*a*) shows a perspective view of one of these brasses or of the pattern for one of them. If the pattern is cut in two lengthwise on the line *a b*, the upper part may be fastened to one side of a plate and the other part opposite it on the other side of the plate, thus making a match plate. The pattern thus mounted is shown in (*b*), in which *a* is the cope side and *b* the back, or drag, side of the plate.

65. Metal Match Plates.—The simplest way in which to make a metal match plate is usually to have a pattern made with double the usual shrinkage allowance and with it make the mold in which the metal match plate is to be cast. The following method saves somewhat in the cost of

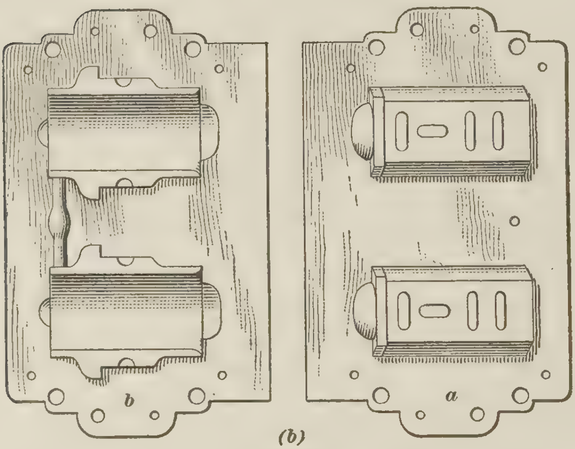
patterns and it may therefore be advantageously used sometimes, even though it requires more work by the molder.

66. Suppose that the metal match plate shown in Fig. 42 (*a*) is to be made. The pattern may be made in two parts to mold the outside surface, but it need not be hollowed out inside. The flange *a* and the plate *b* are made in one piece, and the spherical part the other piece of the pattern.

The cope for the match-plate mold is made from a drag mold that is purposely rammed very hard. The body of the



(*a*)



(*b*)

FIG. 41

pattern, with the flange and plate pattern removed, is put on a bottom board *c*, view (*b*), and the drag molded in the usual way, except that it is rammed very hard. This drag is then turned over, the pattern drawn, and parting sand sprinkled over the joint and inside the mold. The cope is then put on and rammed, as shown in (*c*), and is then set aside for the present. When the cope has been made, the

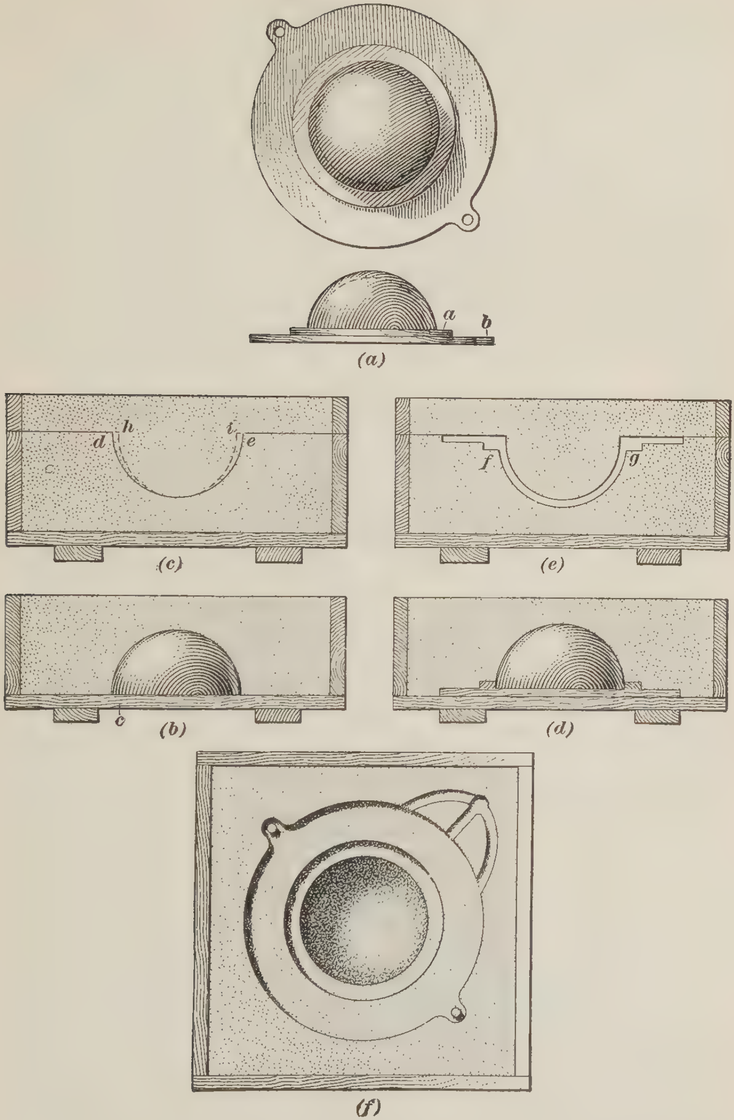


Fig. 42

hard drag is knocked out and a new drag is made with the flange and plate pattern in position, as shown in (*d*). After this drag has been turned over and the pattern drawn, it is ready for the cope; but the cope must receive some troweling before it is ready for use. The width *d e* of the cope is practically the same as the width *f g* of the drag, so that the match plate would not be of uniform thickness. In order to make the thickness of the match plate practically uniform, the cope should be shaved off, as shown by the dotted lines *h i*, and the mold is then ready to be closed, as shown in (*e*). A plan of the drag is shown in (*f*), illustrating one method of gating.

67. In order that the cope and drag molds may fit together properly, the bottom boards on which the first and second drags are made must have some means provided to locate the pattern properly. With the simple pattern here shown, a dowel-pin to fit a hole in the center of the pattern is sufficient; but with other patterns it may be necessary to have two or three dowel-pins placed so that the pattern can be put on the bottom board in only one position. This method of molding the match plate would not be suitable for castings in which the thickness of the metal must be perfectly uniform. Such match plates had better be molded by using a hollow pattern; or, if a hollow pattern would be too thin to have the required strength, two patterns may be used, one to mold the outside and the other the inside surface. When molding a match plate, an important point is that the joint should not be patched; a perfect draw of the pattern must therefore be obtained.

68. Stove-Lid Match Plate.—Match plates for stove lids and other stove castings having lifter holes may be built up in the following manner: Polished-steel plates are fastened to the opposite sides of a hollow frame of which the ears *a*, Fig. 43, are a part. The patterns *b* of the lids are fastened to the cope side of the plate. Bosses *c* are placed where the lifter cavities are to be molded, and opposite these bosses holes *d* are cut in the drag side of the match plate. These

holes are the size of the lifter cavities for which they are to form the green-sand cores. Holes are punched in the sides of the lifter cores to mold the little lugs under which the lifter is placed when handling the lid. These holes are punched by the pins *f*, which may be moved in or out by means of the handle *g* and levers that are enclosed in the hollow part of the match plate.

69. Vibrator Operation.—The use of a vibrator is explained in Art. **14**; but its construction and operation are not considered; therefore, these points are explained here.

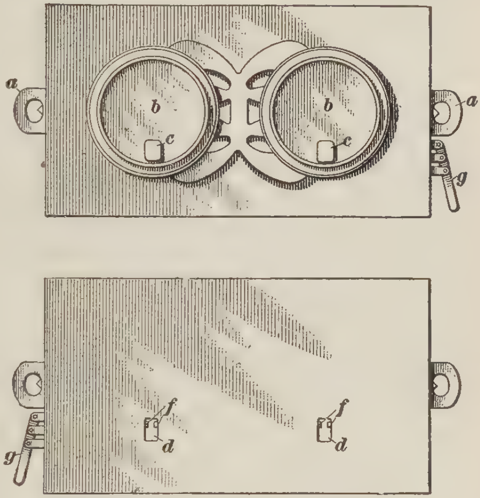


FIG. 43

The section of a vibrator is shown in Fig. 44. The body *a* is a block of metal in which holes are drilled to form the necessary air passages. The plunger *b* moves freely in the large hole in the body. It has steel pieces *c* and *d* at the ends to

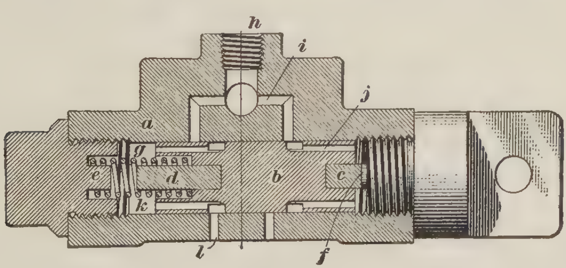


FIG. 44

strike the plugs *e* and *f* in the ends of the vibrator body. The spring *g* holds the plunger in the starting position when the air is not turned on. Air enters through the opening *h* and,

when the plunger is in the position shown, it passes to the right through the passages *i* and *j* to the space at the right-hand end of the plunger. The space at the left of the plunger is in communication with the atmosphere through the passages *k* and *l*, so the plunger is thrown violently to the left, striking the plug *e*. This motion reverses the connections for the passage of the air, thus admitting it to the left of the plunger and exhausting it from the right. These changes take place very rapidly, so that a tremor is set up in the pattern to which the vibrator is attached. Some makers recommend that the weight of the pattern, together with the match board or vibrator frame, should not be more than fifty times the weight of the vibrator plunger.

70. Patterns with Deep Pockets.—Flask bars may be used in flasks that are to be jolt-rammed in exactly the same

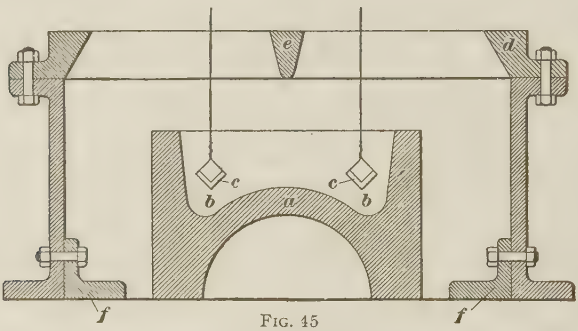


FIG. 45

way as is common in hand-molding flasks. The bars should, however, be **V**-shaped at the lower edge, as the sand will not be tucked under a bar having square corners at the lower edge. Hooked gaggers are also used in the same way as in green-sand molding.

Pockets of sand and similar parts of the mold that need extra support may be held up in ways that give stronger support than when flask bars and gaggers are used. Fig. 45 shows a pattern *a* in which the sand in the pockets *b* might be supported by gaggers; but the following method is more effective: After some facing sand has been put in the pockets,

V-shaped bars *c* are laid in place. Wires are fastened to each end of these bars and the ends of the wires are taken above the top of the cope.

The grid *d*, composed of a frame in which there are **V**-shaped cross-bars that are tied together and strengthened by one or more bars *e* running lengthwise of the flask, is bolted permanently to the top of the flask. The wires from the bars *c* are in pairs, two wires from each end of each bar. These wires should be passed through the grid so that the wires of each pair are on opposite sides of a bar in the grid. Then, after the mold has been filled and jar-rammed, the ends of the wires are twisted together, thus holding the bars *c* in place. The sand at the sides of the pattern may be supported by the joint plates *f*, which are bolted to the flask, as shown.

71. Pattern with Overhung Part.—A portion of a pattern having an overhung part *a* is shown in Fig. 46. The

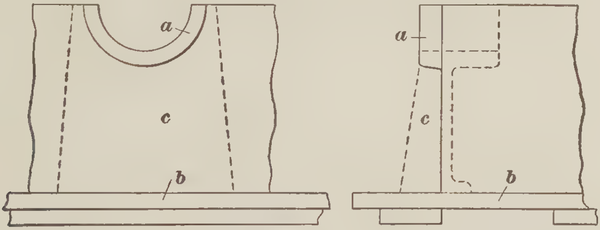


FIG. 46

pattern rests on a match board *b*. In order to draw the pattern, the overhung piece must be made loose, or the space below it must be filled with a block shown dotted at *c*. When the projecting piece and the block *c* are fastened to the pattern and the whole is drawn from the sand, a core of the same shape as the block *c* is set in the mold. It is, however, very difficult to set this core so that a mark will not be made on the casting where the core joins the green-sand part of the mold.

The marking of the casting may be avoided by making the projecting part loose. A loose part will, however, tend strongly to drift toward the joint when the mold is jolt-rammed. In order to avoid this tendency, the loose piece may be supported by a block *c*, which is not fastened to the main pattern

or to the loose piece. When the mold has been rammed and turned over, the match board may be removed and the block *c* drawn from the joint. The print made by the block *c* is then rammed full of green sand by hand, after which the pattern is drawn. Although this method does not avoid the use of the loose piece, it does avoid the use of the dry-sand core and the consequent marking of the casting, and may therefore be preferred when the appearance of the casting is of importance.

DRY-SAND AND LOAM WORK

DRY-SAND MOLDING

INTRODUCTORY REMARKS

1. Dry-sand molding is so called because of the fact that the molds used are first dried or baked, which is done by means of torches or heaters or by placing them in ovens. This method of molding is used in making intricate castings and in circumstances that require especial smoothness, soundness, and accuracy. Castings of large or medium size, such as engine cylinders, mill rolls, gears, and flywheels, and steel castings are usually made in molds of dried or baked sand.

2. In dry-sand molding the same tools and processes are used as in green-sand molding; but dry-sand work has additional or special requirements, such as the selection of the sand to be used, the making of joints, blacking and slicking of surfaces, assembling, gating, and drying. To withstand the temperatures of from 300° to 400° F. that exist in the drying ovens, the flasks for dry-sand molds must be of iron instead of wood.

MAKING DRY-SAND MOLDS

3. The sand for dry-sand molds is usually of two qualities, namely, *backing sand* and *facing sand.*

4. Backing sand is used to fill up between the flask and the layer of facing sand next to the pattern, and is usually a black mixture of burnt facing sand, other sand, cinders,

and clay mixed with water. Care should be taken to pulverize the heap of backing sand and free it from lumps of wet sand and mud, as the moisture is not so easily driven off from the lumps as from the fine material, and the mold may be unevenly dried. Defective castings may result from the driving off of the retained moisture by the hot metal when the mold is poured.

5. Facing sand for dry-sand molds is coarser than that generally used for green-sand molds. The heavier the casting, the coarser or more open the facing sand should be. Coarse, open sand does not cause a rough casting, because the face of the mold is smoothed with blacking. In some localities facing sands naturally suited for dry-sand molds are found, notably in New Jersey and in the vicinity of Hamilton, Ohio. A mixture composed of half new and half old of either of the sands mentioned, without the addition of any binding material, makes a first-class facing. Sharp sand and a binder, such as flour or pitch compound, must be mixed with common molding sands to make them suitable for facing dry-sand molds. The amount of sharp sand and of binder depends on the natural bond of the common sand. A mixture composed of 7 parts of coarse molding sand, 7 parts of coarse bank or river sand, and 1 part of flour is sometimes used as a facing. The materials must be thoroughly mixed and dampened with molasses water or clay water.

6. Some experimenting is usually required with any stock of materials in order to produce a good, reliable facing. For this reason, it must not be expected that the various receipts given for facing sands are to be used without change. The proportions will usually need to be altered to produce a satisfactory sand to suit particular conditions.

7. Facing-Sand Mixtures.—One suggested mixture for facing sand consists of 10 parts of molding sand, 10 parts of loose bank sand, and 1 part of flour, the whole being mixed in a dry state and tempered with a thin clay wash; or, 15 parts of molding sand, 15 parts of loose bank sand, and 1 part of

pitch compound may be used, with the addition of the clay wash.

A facing sand suitable for use in the Eastern States may be made of 30 parts of Millville gravel, 20 parts of old heap sand, and 1 part of pitch compound. Another, for use in the Middle States and the Middle Western States, is composed of equal parts of Hamilton sand and old heap sand without any flour or pitch compound.

8. Ramming Dry-Sand Molds.—A dry-sand mold must be rammed hard enough to prevent the surfaces from yielding under the pressure of the metal when the casting is poured. The deeper the mold, the greater will be the pressure exerted by the molten metal, and therefore the harder must be the ramming. If the sand is of the proper quality and the molds are well dried, there is no danger in ramming too hard; but if a deep mold is rammed extremely hard at the bottom, extra venting must be employed, as by a cinder bed or other means.

9. Venting Dry-Sand Molds.—The cinder bed forms a common and effective means for venting dry-sand molds, whether they are made in flasks or in pits. It should never be closer than 6 inches to the pattern; otherwise, bodies of gas will be brought close to the face of the mold and a sudden pressure, such as that produced by an explosion following a lighting of the vents, may cause badly scabbed or buckled castings. A cleaner method of venting is to use rods, when this can be done. As shown in Fig. 1, a number of rods *a* of convenient size are put through holes in the sides of the flask *b*, at the proper distance from the face of the pattern *c*. The mold is rammed up, the bottom plates are clamped on, and then, before the drag is rolled over, the rods are withdrawn,

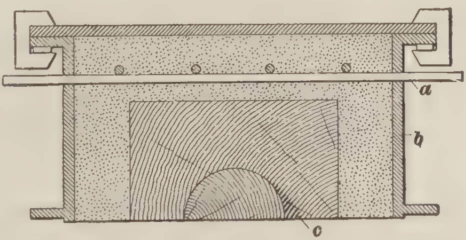


Fig. 1

leaving vents in the mold. The vent wire is not used so much as in green-sand molding, because no steam is formed during pouring of a dry-sand mold; also, the sand should be coarse and open enough to render a vent wire unnecessary. Occasionally, a pocket or a projection in some work will require venting with a wire and sometimes molds are vented with a wire after being rammed up, so as to hasten drying, as the steam is supposed to escape more easily.

10. Securing Sand in Dry-Sand Molds.—As a general rule, fewer gaggers and rods are needed to hold the sand securely in a dry-sand mold than in a green-sand mold; but if the sand has a weak bond and crumbles easily when green, the contrary will be true. The beginner must use his judgment as to the number of gaggers and rods, and it is better to make the mistake of using too many, until he becomes accustomed to working with the material and discovers just what amount of support it requires.

11. Joints of Dry-Sand Molds.—After a pattern has been drawn from the mold, the first thing of importance is to slick down the joints; for if this is not done, they may project in places and a crush may be caused when the cope is closed on the drag. It must be remembered that when a

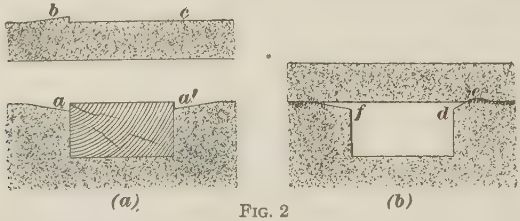


Fig. 2

mold is made of green sand and the joints come snugly together, they may be compressed a little without doing harm. With dry-sand work, if the faces of the joints press each other in the least, one of them must give way, and this may result in the loss of a casting. When making a joint, one plan to avoid a crush is to slick down the joint, as shown at *a*, Fig. 2 (*a*), instead of leaving it flush with the pattern, and in finishing

the cope to cut down the projection at *b* and leave it flush with the surface of the cope, as at *c*. Another plan is to make the joint of the mold even with that of the pattern, so that the cope will be level when it is lifted off, and then to cut down the drag joint, as at *a′*, before drawing the pattern. A quicker and safer way to do this, however, is to lay a piece of board about 4 inches wide and 10 inches long on the joint and hammer it down and then to slick up any roughness with the trowel.

12. Either of the plans just described will cause the joint to appear as in Fig. 2 (*b*) when the cope is closed. The small ridge of metal that flows out along the joint of the mold is called a *fin*. Some molders in finning a joint will merely slick the edge as at *d*, pressing it with a trowel. Such a joint is more likely to crush than if no attempt were made at finning, for the reason that the trowel is apt to raise the sand as at *e*. A fin should slope back gradually from 3 to 4 inches, as shown at *f*, and its thickness at the front of the mold can range from $\frac{1}{8}$ to $\frac{1}{4}$ inch, depending on the liability of crushing due to a bad flask joint or to the poor drawing of the pattern. Whenever there is danger of crushing, the fin should be large. The molder should bear in mind that it is better to have a fin than a crush. The fin at *f* can easily be broken off close to the casting and dressed up in a short time with the chipping hammer; but a fin like that at *d* cannot be broken off well, and must be chipped off, which takes time and adds to the cost.

13. Slicking and Blackening Dry-Sand Molds.—After the joint has been properly cut to form the fin and the pattern withdrawn, the mold is sprinkled lightly with water or molasses water, according to the strength of the sand, either by a brush or by a spraying device. The mold is then slicked up smoothly with finishing tools, after which a coat of blacking is applied with a soft brush, a swab, or a sprayer. The blacking should be put on as evenly as possible and in such a manner as not to show the streaks of the brush or swab, as these leave an uneven surface. After the mold has been blackened, it is slicked

over as evenly as possible, so as not to show the marks of finishing tools on the surface. On green molds for heavy work, as least $\frac{1}{32}$ inch of blacking should be applied. This thickness will peel any casting if the material is good. There is generally little difficulty in peeling flat surfaces to get them smooth and true to form. The skill of the molder is largely shown in the finish of the corners, fillets, flanges, etc. of a casting.

14. Blackening molds after they are dry is an old-fashioned method and is employed very little in present-day practice; but if for any reason it must be employed, the blacking used must be very much thinner than that used for blackening the mold in a green state, and the mold must not be too hot or the blacking will blister and come off, forming scabs. No attempt should be made to slick the blacking on dry molds, as this cannot be done advantageously; instead, it should be put on evenly with a brush. In slicking blacking on the corners and edges of molds, care should be taken to use the same fillet tools that were used to slick the mold before the blacking was applied. If this is not done, the blacking will curl up behind the tool, which will give the mold a sloppy appearance and may cause scabs on the casting.

15. The blacking on many dry-sand molds is not slicked, For example, the blacking on molds for water and gas pipes. ingots, and similar work is not slicked, nor is it on many of the better classes of work when put on by sprayers. In addition to the trowel, such special tools as corner tools, print tools, and fillet tools of different sizes are used to finish and slick the blacking on the better classes of dry-sand molds. It takes practice to become expert in the use of finishing tools; but the inexperienced workman is apt to take too much time for finishing and slicking with them until he becomes accustomed to their use. The surfaces of molds are more easily slicked when they are thoroughly wet than when they are only moist. For this reason, some molders throw plenty of water on the molds, in the belief that no harm will result, as the mold is dried before it is poured. This belief is altogether wrong, however, particularly if the sand is of a loamy nature. In

slicking, much of the clay in it is brought to the surface, closing up the pores and to some extent preventing the surface from sticking to the sand behind it. The result is that, when the mold is poured, the steam and gases formed force parts of the surface loose and scabs are formed on the casting.

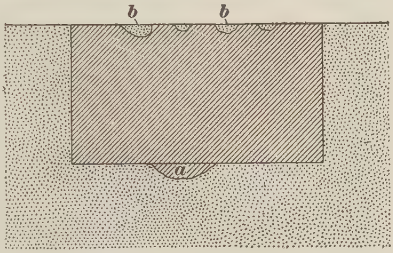


FIG. 3

16. Scabs and Buckles. There is a difference between a scab and a buckle, both of which are common defects in castings. A scab is a knob or bulge on the surface of a casting, due to the displacement of some of the sand forming the mold. For example, in Fig. 3, a part of the sand at a is dislodged when the casting is poured and the metal that fills the space thus left forms a rough bulge, or scab, on the casting. The sand rises with the metal, is broken up and comes to rest against the cope, as at b, where it forms pits, or holes, in the casting. If the sand is displaced after the mold is wholly or partly filled, it may rise until it is completely enclosed by the metal, as at a, Fig. 4. Not until the metal at b is chipped or machined off is it discovered that the displaced sand is imbedded in the casting. If the lump of displaced sand floats up and rests against a core, as at a, Fig. 5, the removal of the scab b will leave a hole through the casting and cause it to be condemned. A buckle occurs when a part of the surface of a mold is bulged inwards,

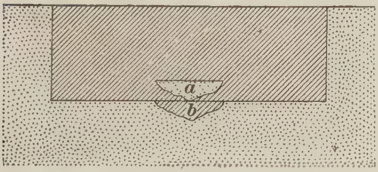


FIG. 4

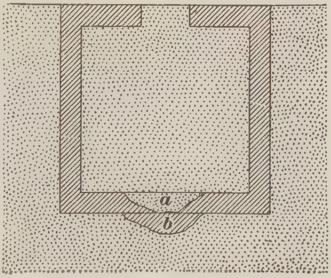


FIG. 5

but not torn altogether loose from the backing, thus forming a depression in the surface of the casting. Scabs and buckles are often due to bad materials; but they may also be caused by poor work on the part of the molder.

17. Drying Dry-Sand Molds.—Dry-sand molds may be dried in ovens, similar to those used for drying cores, or on the floor of the foundry. The latter method is used for work in pits and for other work that is too large for the ovens. It is similar to skin-drying and is often called by that name; but in reality it is a form of dry-sand work requiring great skill. The work is not often dried throughout, a skin of 1 or 2 inches being considered sufficient in most cases. The heavier the section, the heavier is the casting and the deeper must the sand be dried, because of the greater heat brought against the walls of the mold and the longer time during which the metal remains in the molten condition.

18. Probably the most common method of drying molds on the floor is to use a charcoal basket suspended inside the mold. In regions where natural gas is plentiful and cheap, it is used to a great extent, and oil burners are being used more extensively for this purpose. Coke and hard coal may be used if the molds are large enough to contain stoves in which these fuels can be burned. Sometimes the hot-air method is employed. A special form of stove on top of the mold heats the air, which is conducted down into the mold by pipes through openings in the cope. When this method is used, the cope is usually placed on the top of the mold while in a green state. The method of drying to be used is largely a matter that is decided by the usual practice of the foundry and not by the individual molder.

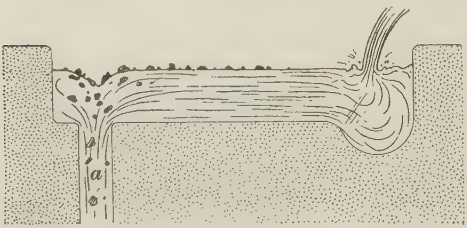


Fig. 6

19. Gating Dry-Sand Molds.—In gating work that must be clean, it is not wise to use a single large gate, as shown

at *a*, Fig. 6. If this is done, the dirt picked up by the stream of metal during pouring will be carried down by the suction formed just above the gate. A better plan is to use a number of smaller gates *b*, as shown in Fig. 7. The suction effect will be greatly reduced and the dirt will float on the surface of the metal, as at *a*, without being drawn down. The smaller gates will thus act as skimmers. The runner basin should be as narrow as possible and from 6 to 8 inches deep. If it is not made narrow, dirt will be sucked down the gates even with the most careful pouring. The dirt may be kept floating by making a deep basin, and the larger the gates, the deeper should be the basin.

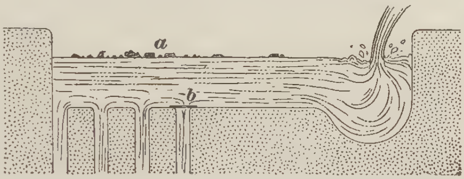


FIG. 7

20. One method of preventing dirt from being carried into the mold is to cover each down gate with a small piece of tin plate having a $\frac{1}{4}$-inch hole in the middle, as shown over the gate *b*, Fig. 7. When the pouring begins, the metal will trickle through the hole, the tin will be melted away, and the gate opened fully; but by that time the basin will be filled to a sufficient depth to keep all the dirt floating. Of course, none of the methods just described will prevent dirty castings if the metal is bad, dull, or dirty, or if dirt is formed in the mold by scales or scabs. Some molders seem unable to get the cope side of a casting clean; but this trouble is due to ignorance of proper methods. The top or cope side can be made as clean as the bottom if dirt is prevented from entering the mold with the iron by using the methods given.

ASSEMBLING DRY-SAND MOLDS

21. Prevention of Crushing.—Considerable care and skill must be used in closing and clamping dry-sand molds, particularly when many cores are to be set and secured in place. If the flasks are in good condition, with joints that match well and bear properly on one another and the joints

of the mold are correctly made, there is little danger of crushing when the mold is assembled. However, to prevent any crushing due to squeezing, iron wedges or other iron packing should be driven tightly between the flanges of the flask before they are bolted or clamped together. These wedges should be driven in securely, but not to such an extent as to lift the cope from the drag even in the slightest degree.

22. Use of Packing.—As no two dried parts of a mold will fit together perfectly, some packing material must be used between them to insure a fit and to give them an even bearing. Rolls of dough from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter are considered best for this purpose; but sometimes clay rolls and thick flour paste are used. Dough rolls are very soft and when the mold is put together they flatten out under the pressure until they form a very thin layer. The parts of the mold are thus kept apart only a very slight distance. Clay rolls will not flatten so readily, even when they are as wet as they can be used, and as a result they cause a thicker fin to be formed, because the parts of the mold are held apart farther. A clay roll $\frac{1}{2}$ inch in diameter will not flatten out to less than $\frac{1}{8}$ inch in thickness, and if the clay is stiff it will not flatten that much. If the weight of the mold is brought on this small ridge or bearing, a bad crush may result; therefore, it is wise to avoid the use of clay except on parts of the mold that are to be separated to increase the thickness of metal or to bring up extra thickness on a core that may be too small for the core print.

23. Use of Chaplets.—The cores of dry-sand molds must be set with the greatest care, and if chaplets must be used, they should be located with good judgment. The length of the stem of the chaplet depends on the thickness of the casting; but the thickness of the stem rests on the judgment of the molder. If the chaplets are used merely to prevent side shifting of a hanging core, they may be made lighter than when used to support the core. The temperature of the metal, the thickness of the casting, and the necessity of having the casting tight against steam or water pressure will influence

the kind, form, and size of chaplets to be used. If there is danger of leakage, as in work intended to hold water or steam, the chaplet should have as thin a stem as possible; but it should not be too light, or it will be melted by the hot metal and the core will float. Chaplets should not be placed in the path of a stream of metal; but if this cannot be avoided, chaplets of very heavy steel should be used.

24. Sometimes the occurrence of leaks in castings cannot be prevented, as, for example, in a large pipe elbow 1 inch thick. When the diameter of the core is large, as in this case, and the tendency to lift or float is great, an added thickness of metal around the chaplet must be used. This additional metal forms what is known as a *button*. It is formed by scooping out the sand around the stem of the chaplet, as at *a*, Fig. 8 (*a*), and when the casting is poured, it appears as shown in (*b*). The steel chaplet may then be peened to make it tight, or it may be drilled out and a pipe plug of proper size inserted. If the sand is not removed carefully, the button will have the slovenly appearance shown in (*c*). The height of the button should be equal to the diameter of the stem of the chaplet. At the small end it should be twice, and at the large end about two and a half times, the diameter of the chaplet.

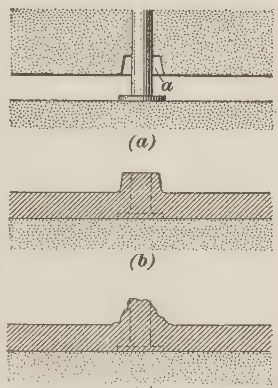


FIG. 8

25. Securing Dry-Sand Molds.—After a mold is closed, it should be secured carefully to prevent run-outs, strains, lifting or floating of cores, or explosions; otherwise, lives may be endangered and the spoiling of the casting may cause considerable financial loss. Molds may be secured by bolts or by clamps and sometimes both are employed, a few bolts being used at the most important points and clamps at the other points. Bolts are not greatly favored by molders, because they rust after being used a few times and thus become useless.

The space between the flanges of the flask should be packed with sand or mud before the clamps are put on, to prevent the escape of the molten metal. A mold with joints thus packed is shown in Fig. 9. The flanges are separated by an iron wedge *a* to prevent crushing of the mold and sand or mud is packed tightly between them, as at *b*. The parts of the flask are held together by clamps *c* that are drawn tight by iron wedges *d*, which are driven in between the under flange and the clamps. Wooden wedges may be used on small work, where the stresses are not great; but large work should be secured with iron wedges.

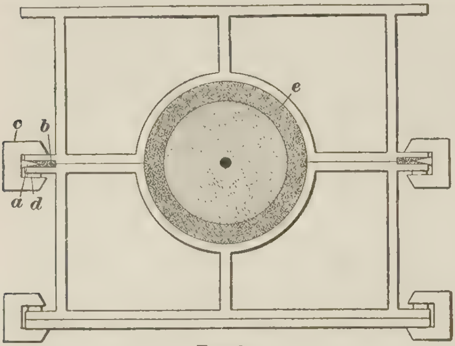


FIG. 9

26. Stopping Up End of Mold.—If a flask for a cylindrical mold is open at the ends for the core, it may be stopped up by using bricks and mud or mortar made from old molding sand. Enough mud must be used to fill up all the spaces between the bricks, and between the brickwork and the core or other surfaces with which it comes in contact. The appearance of the end of a cylindrical mold after being bricked up is shown in Fig. 10. The care with which the bricks are chipped to conform to the end of the flask is plainly shown. One or two iron or wooden wedges should be driven over the top, or key, bricks, as at *a*, while the mud is still fresh, so as to tighten the whole wall.

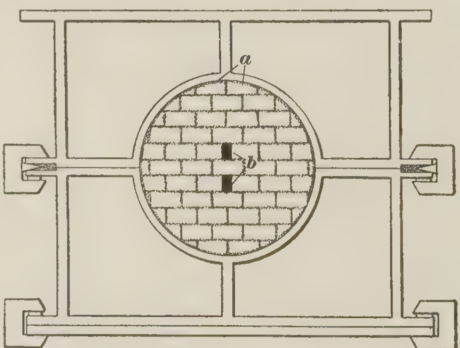


FIG. 10

The object of the tight wall is to prevent a run-out. The openings *b* at the center connect with the vents in the core and allow the escape of gases during pouring. The ends of small cylindrical molds may be secured by ramming stiff, new sand or mud into the space between the core and the flask, as at *e*, Fig. 9. This space should be about 1 inch wide. The end of the flask may be stopped in other ways, as, for example, by using an extra loose bar in the flask or boxes on the outside; but as both of these methods involve the use of larger flasks, they are not recommended. The mud used in the method described should be allowed to dry or stiffen somewhat before the mold is poured.

MOLDS FOR CHILLED CASTINGS

27. Nature of Chilled Castings.—A **chilled casting** is one that is cast in a mold made either wholly or partly of iron. The object of the iron mold is to remove the heat rapidly and so harden the iron by retaining the carbon in the combined form. The manufacture of chilled castings is a branch of founding that has cost founders more money, time, and labor to bring to a successful stage than any other branch. The difficulties experienced were in preventing the chilled parts from being checked or cracked, and also in obtaining the right character and depth of chill. The factors that affect the character and depth of chill are the nature of the iron used, the thickness of the iron mold, and the pouring temperature of the metal.

28. Construction of Chill.—A vertical section of a mold for a chilled casting is shown in Fig. 11 (*a*). The part that does the chilling, known as the chill, and sometimes as the chiller, is a heavy cast-iron cylinder *a*, whose internal diameter *d* is equal to, and whose thickness *e* depends on, the diameter of the casting. The chill is made in one piece in this case, because the roll that is to be cast inside it is of the same diameter throughout, and therefore can be slipped out of the chill readily after cooling. The iron of which the chill is made must possess both strength and ductility to allow for

alternate expansion and contraction. If poorer grades are used, the chills may be cracked at the first pouring and will not last long in any case.

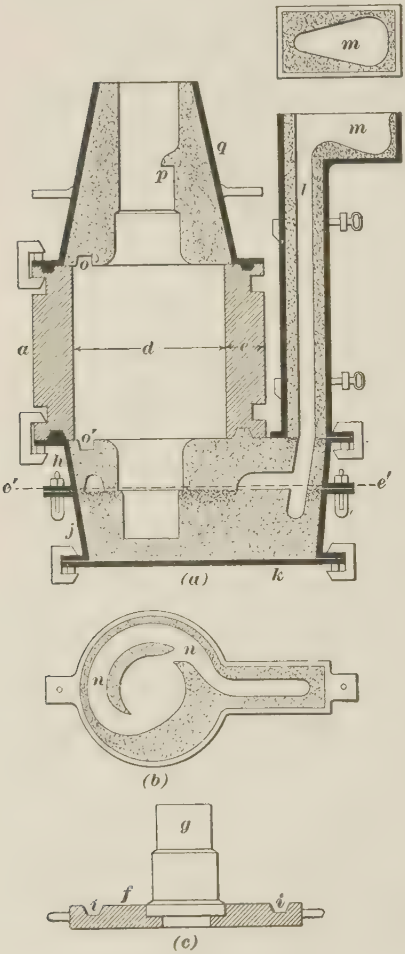


FIG. 11

29. A chill for a roll that is long in the body may be made in sections, as in the mold shown in section in Fig. 12. The sections are turned on their adjacent ends so as to make a tight joint at *b* and flanges *c* are cast on the outside so that they may be bolted together securely. Great care must be taken to turn the faces of the sections accurately, as the joint must be air-tight. Any openings at the joint will cause chill cracks and spoil the casting. Whenever practicable, therefore, the chill should be made in one piece instead of in sections. The inside surface of a chill must be finished as true and smooth as possible in the lathe and care must be taken to prevent the finished surfaces from being rusted through exposure to dampness. When chills are not in regular use, their surfaces should be coated with some good oil or grease, which must be rubbed off before the chill is used again.

30. Thickness of Chills.—The thicker the body of a casting is, the greater must be the thickness of the chill. This

rule is not so much for the purpose of resisting the pressure of the molten iron as to provide a body of metal that will act as a rapid conductor of heat from the molten iron and thus chill the surface of the casting, and also to prevent the chill itself from being cracked when suddenly heated. Table I gives the thicknesses of chills for rolls ranging from 4 to 30 inches in diameter and varying in length from 2 feet in their chilled section up to the size required for the common length of rolls. It will be noticed in the table that for rolls more than 9 inches in diameter, an increase of $\frac{3}{8}$ inch in the thickness of the chill is allowed for every inch of increase in diameter of the roll. Thus, in Fig. 11, the diameter d is 18 inches; hence, the thickness e of the chill a is $3\frac{3}{8}+(9\times\frac{3}{8})=6\frac{3}{4}$ inches. In Fig. 12, the diameter d is 14 inches and therefore e is $3\frac{3}{8}+(5\times\frac{3}{8})=5\frac{1}{4}$ inches. If the body of a chill is made too light, the chill is in danger of being cracked when suddenly heated.

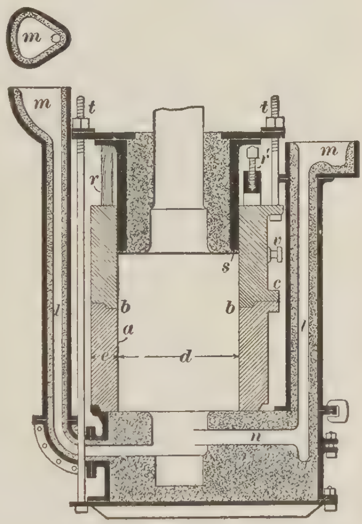


FIG. 12

31. Making Mold for Chilled Casting.—The sectional view of a mold for a chilled roll, ready for casting, is shown in Fig. 11 (a), and a cross-section along the line $e'e'$ is given in (b). In starting a mold such as here shown, the mold board f, shown in (c), is first set on solid ground and the neck pattern g of the roll is put in place. The section h of the flask, in (a), is set on the mold board with its projection fitting into the grooves i, in (c), which serve to keep it central. The section h, in (a), is rammed up, a joint is made, and the bottom part j of the flask is set on this section and rammed up. The bottom plate k is next set on and clamped, the whole arrangement is rolled over, the pattern drawn, the mold finished,

the middle section *h* lifted off, and a whirl gate *n* made as shown in (*b*). The molds for both chilled rolls and sand rolls are, as a rule, made in dry sand; the methods of ramming, venting, finishing, blackening, and drying are the same as with all dry-sand molds. The upper neck of the roll is rammed in the same manner as the lower neck.

32. In the molding of a chilled roll, it is always very important to attach a whirl gate, such as is shown at *n*, Fig. 11 (*b*), so that the metal will enter the mold with a whirling motion, which will cause all the dirt to gather in a body

TABLE I

THICKNESS OF CHILLS FOR ROLLS

Diameter of Roll Inches	Thickness of Chill Inches	Diameter of Roll Inches	Thickness of Chill Inches	Diameter of Roll Inches	Thickness of Chill Inches
4	2	13	$4\frac{7}{8}$	22	$8\frac{1}{4}$
5	$2\frac{1}{2}$	14	$5\frac{1}{4}$	23	$8\frac{5}{8}$
6	3	15	$5\frac{5}{8}$	24	9
7	$3\frac{1}{8}$	16	6	25	$9\frac{3}{8}$
8	$3\frac{1}{4}$	17	$6\frac{3}{8}$	26	$9\frac{3}{4}$
9	$3\frac{3}{8}$	18	$6\frac{3}{4}$	27	$10\frac{1}{8}$
10	$3\frac{3}{4}$	19	$7\frac{1}{8}$	28	$10\frac{1}{2}$
11	$4\frac{1}{8}$	20	$7\frac{1}{2}$	29	$10\frac{7}{8}$
12	$4\frac{1}{2}$	21	$7\frac{7}{8}$	30	$11\frac{1}{4}$

in the center of the casting, and thus bring it up into the top feeding head and give the chill a face free from dirt. If it were not for the whirl gate, the dirt would be more or less apt to go to the outer body of the casting and form dirt holes or defects that would condemn it. In making the runner *l* and pouring basin *m*, shown in Figs. 11 (*a*) and 12, as much care is necessary as in the construction of the mold. They are made of dry sand and then black-washed in the same way as the mold. The projection *p*, Fig. 11 (*a*), serves to reduce the size of the feeding head at its junction with the

neck of the roll and thus permit it to be broken off with a sledge. To insure a more solid casting, the usual practice is to make the feeding head of the same diameter as the neck of the roll and cut it off in the lathe when finishing the casting.

33. The completeness of detail of Fig. 11 (*a*) will make clear the processes of closing, clamping, etc., in getting the molds ready for casting. The object of the little depressions at *o* and *o'* is merely to furnish pieces on the casting about 1 inch deep by $\frac{3}{4}$ inch thick, which may be knocked off to show the depth of chill in the roll before it is accepted or placed in the lathe. In order to free the runner *l* and basin *m*, the runner casing is made in sections. The contraction of the casting permits its easy removal from the chill after the cope *q* has been removed. Chilled castings are generally not taken from their molds until they have cooled down to a temperature below what would show a red heat in the dark; it is better, where possible, to leave them until they are nearly as cool as the atmosphere.

34. Heating and Blackening of Chills.—The surface of the chill may with advantage be heated in an oven or by a fire inside the chill to a temperature of from 100° to 200° F. before closing the mold for casting. As a rule, it is advisable to coat the surface of the chill with a thin solution of black lead and molasses water. The amount of molasses used depends on its strength, the usual proportions being about $\frac{1}{4}$ pint of molasses to 1 pail of water. If the solution is too strong in molasses, the blacking will be cracked and checked when dried. Care must be taken in using this wash on the surface of chills, since the use of a material that will produce gas may have a worse effect than if nothing were used. Light oils are sometimes used instead of blacking for the surface of chills; but in such cases care must be exercised to have just as thin a coat of it on the chill as is practicable. By using a heavy coating of oil gas is created and the metal thrown back from the face of the chill as it rises in the mold, the result being rough and cold-shut spots on the surface of the casting, which would condemn it.

35. Vertical Contraction of Roll.—Vertical contraction of the body of the roll in cooling has often caused trouble by pulling off the upper neck or else making invisible cracks that have caused it to break when put into use. Different methods of guarding against this trouble have been adopted. One plan, shown in Fig. 12, is to make a cast-iron sleeve *s* about $\frac{3}{4}$ inch thick, which sleeve is turned on the outside so as to fit easily into the chill to a distance varying from 6 to 20 inches, according to the length of the roll desired. The upper neck of the roll is molded in this sleeve in the ordinary manner. In closing the mold, the height of the neck desired is regulated by placing in position three blocks *r* or three jack-screws *r'*. These blocks can be of either iron or wood, their length being made to suit the requirements. The neck mold or sleeve is held in place by bolts *t*. After the mold has been cast, the sustaining blocks *r* or the jack-screws *r'* are removed, after which the nuts on the bolts *t* are tightened occasionally so as to compel the sleeve *s* to follow the contraction that takes place. Of course, the screws are not tightened until solidification begins.

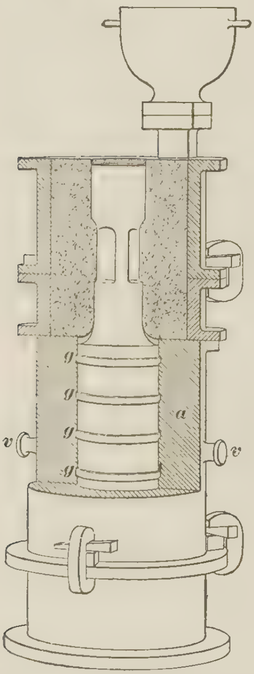
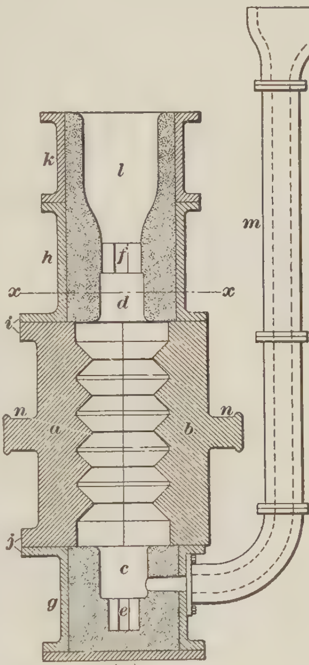


Fig. 13

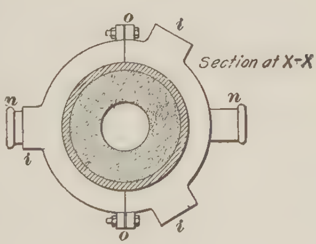
36. Another difficulty experienced in casting chilled rolls, car wheels, and similar work is in obtaining an even depth of chill all around the outer surface of the casting. This is a matter of considerable importance in some classes of work. In Fig. 13 is shown a method used to obtain a uniformly chilled roll. The principle involved is that as the roll contracts lengthwise, the grooves *g* in the chill *a* will compel the casting to remain central in its mold, so that the chill can have the same cooling effect all over the body of the casting.

This is further accomplished by grooving or otherwise fixing the parts of flasks or chills that hold the bottom and top necks so that they cannot move from their connections with the chill. The sand is of a solid, firm character, so as not to allow sufficient burning action to occur to permit the bottom or top necks of the rolls to move from their positions. The illustration also gives a good idea of the formation of chills and of the methods of molding and casting chilled rolls. It also shows how rolls will settle down in contracting lengthwise. The grooves are shallow and when the roll is cold it will have contracted sufficiently to allow it to be lifted out of the chill, or the chill to be lifted away from it.

37. Mold for Grooved Roll. A vertical section of a dry-sand mold and chill for a deeply grooved chilled roll is shown in Fig. 14 (*a*). The chill is made in halves *a* and *b* that are bolted together. This is necessary, as the roll is grooved and could not be removed unless the chill could be opened. The bearings *c* and *d* of the roll and the ends *e* and *f* are formed in dry-sand molds. The drag *g* and the reducer *h* are fastened to the chill by clamping together corresponding lugs on the pieces, as at *i* and *j*. There are three lugs at each end of the chill and corresponding lugs on the adjacent sections, as shown in the cross-section (*b*).



(*a*)



(*b*)

FIG. 14

The top section *k* in (*a*) forms a riser *l*. The runner *m* is formed of several sections of pipe lined with clay, and the lowest section is firmly bolted to the drag *g*. The trunnions *n* enable the chill to be lifted away from the drag *g*. The halves of the chill are bolted together as shown at *o*, in (*b*).

38. Making Chilled Car Wheels.—In casting chilled car wheels, it is desirable to obtain an even depth of chill. To insure this, contracting chills are sometimes used. These are so constructed that as the wheel contracts, the chill is closed in to keep in close contact with the casting. The general practice is to use solid chills *a*, Fig. 15, ranging in thickness from 4 to 5 inches. Trunnions are cast on these

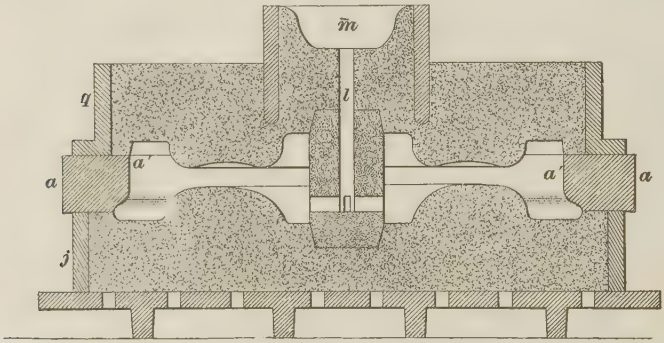


Fig. 15

chills, by which to handle them, as in the case of the trunnions *v* on the chill shown in Fig. 13. The cope *q*, Fig. 15, and the drag *j* are guided centrally with the chill by means of dowel-pins and plates. The wheels are molded in green sand in the usual way, and are then cast by having metal poured into a basin *m*, from which it flows into the mold through the gate *l*. In many cases the gates are made on the end of the hub at the side of the core in place of through it. The depth of the chill on the tread *a*′ of the wheel generally ranges from $\frac{1}{2}$ to $\frac{3}{4}$ inch; it should be very hard, to withstand the usage encountered in railroad service.

39. Annealing and Testing Chilled Car Wheels. After the wheels have solidified, they are taken from the

molds and put into annealing pits holding eight or more. The wheels are left there for 2 or 3 days, after which they are hoisted out and cleaned. The annealing is done to relieve the wheel of internal strains and thus prevent its being cracked when in use. After the wheels are cleaned, they are inspected. One wheel is taken out of every batch of fifty and is subjected to thermal and drop tests to prove its fitness for acceptance. In making the thermal test, a channel is formed in green sand around the tread of the car wheel. Iron is poured into this channel and allowed to cool around the wheel, after which the wheel is removed. If any cracks are noticeable in the tread when the wheel has been removed from the ring of metal, the wheel is condemned; and if it is representative of a batch of wheels from the same cast, all are condemned. In making the drop test, a special weight is dropped from a certain height on the hub of a wheel as it lies flat. If the wheel is cracked under fewer than the prescribed number of blows, it is condemned, in the same manner as for the thermal test.

40. Other Types of Chilled Castings.—There are several classes of rough castings that are made in chills, perhaps the most common being sash weights for windows. Half of the mold is in the cope and the other half in the drag, as in any other mold, and the gate or runner must be constructed of loose pieces so that it can be broken or hammered out easily. Similarly, chilled balls must be made in a mold having two parts hinged together, and the gate or runner must be on the joint so that they can be knocked out of the mold. The outside of service pipes and standard cast-iron pipe fittings can be made in chill molds, but the inside or core must be made in sand, preferably green sand. With the exception of sash-weight molds, which are usually arranged in gangs on continuous iron horses, molds are made to open like a book. Intricate castings cannot, as a rule, be made with any great degree of success in chill molds. Chills are expensive to make and last only a short time, and the contraction of the castings made in them usually limits their use to things of two parts.

MOLDING IN LOAM

APPLICATION OF LOAM WORK

41. Nature of Loam Work.—A **loam mold** usually consists of a backing of brick faced with loam that is swept up to the desired size and shape, and in this respect it differs greatly from either green-sand or dry-sand work. Pieces of patterns are set into the walls at the points where projections of any kind are required. Full patterns are seldom used in loam molding, except for pieces that cannot be swept up or in case so few castings are required that it would not pay to build a flask for them. Loam molding is one of the oldest methods known, but it seems to be less understood than the other methods. Some shop managers who are familiar with all the methods of molding are sometimes compelled to go against their own judgment and adopt other methods because they cannot find molders who understand and can follow instructions on loam work.

42. Advantages of Loam Molding.—Loam molding can be used to make castings that, because of their great size and weight, could not be made safely by any other method. It can also be used to reduce the cost of labor, as in many cases it is possible to use loam molding and obtain better and truer castings at less cost than by other methods. Such castings as large engine cylinders and heavy flywheels can be made very successfully in loam. If this method were better known it would be employed more widely on large and medium work, because no flask and little or no pattern work are required. Contrary to general opinion, it is not a slow method, this idea being held usually by those who either do not know or who have tried it on work to which it was not adapted. Each method of molding has its proper application, but only

comparatively few know how to apply the different methods to reduce cost and improve castings.

43. Permanent Loam Molds.—Loam molds are often made permanent, so that a number of similar castings can be produced from the same mold. The labor of making the mold is thus confined to that for the first casting, some minor patching being sufficient to keep the mold in condition for the succeeding castings. If the number of castings to be produced is great enough to warrant the expense, the mold may be built up of firebrick. A permanent mold is built much more substantially than a mold intended for one casting. It is often bound and bolted together so securely that the brickwork is not apt to be damaged even if the mold is handled roughly.

MATERIALS AND EQUIPMENT

44. Loam.—The loam that is used in making loam molds is a mixture of molding sand and clay. While being used it is wet until it has the consistency of mud. Some natural sands are found, such as Hamilton sand and Millville gravel, that answer the purpose alone; but usually sand and clay must be mixed to obtain a loam that is satisfactory and that approaches either of the natural sands in quality. A good loam must be open and porous when dry, and must also be hard and strong enough to withstand the cutting action of the molten metal that runs against it. It must be fairly refractory, so that it will not burn easily when drying, and it must have no tendency to form scabs or buckles while the mold is being poured.

45. In many localities in which loam molding is practiced it has come to be the settled opinion that a good loam cannot be made without the admixture of horse manure, sawdust, finely cut straw, or some similar material to give the desired porosity. The use of these materials to produce an open loam is not necessary, for coarse sand or gravel will answer the purpose just as well and will make the loam cheaper and easier

to mix. Sands vary so much in quality that any formula or receipt for loam that might be given would work well only in a few localities. The best plan is to try various mixtures until one is obtained that gives good results. Coarse plaster sand, obtained from either a bank or a river, when mixed with molding sand and clay, will make a good loam. A loam that is too close will crack during drying, and therefore more sharp sand should be added. One that is too open will not withstand the drying fire nor the cutting action of the molten metal. Loam may be mixed with a common garden hoe in an ordinary mortar box.

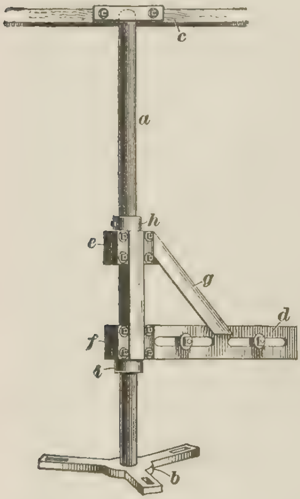


FIG. 16

46. Bricks.—The bricks that are used to build the backing on which the loam is held must be soft and capable of absorbing water in large quantities, because the greater part of the moisture in the loam must be taken up by them. The more porous the bricks, the more rapidly will they absorb moisture. It is an advantage to have the moisture absorbed quickly, as the loam and mud will then stiffen quickly and tools can be used on the mold to smooth and finish it. The mud referred to consists of old sand wetted until it has the consistency of mud. It is used as a mortar in laying the bricks and is applied by the hand instead of by a trowel.

47. Sweeps and Spindles.—It is usually necessary to use sweeps and spindles in making loam molds. A sweep is a board or a combination of boards chamfered to form a fairly sharp cutting edge and shaped along that edge so as to give the loam the desired form of the casting. It is attached firmly to an arm that can be rotated on an upright rod or column called a spindle. A spindle and an arm for holding a sweep are shown in Fig. 16. The spindle *a* is held in its

correct position by the spindle seat or centering plate *b* at the bottom and the guide *c* at the top, the latter being fixed to a wall bracket or to some other rigid support. A spindle held by a top guide is called a stationary spindle.

48. In some cases it may not be possible to use an upper guide for the spindle, and a portable spindle must be employed. Such a spindle is shown in Fig. 17 (*a*) and (*b*). There is only one guide *a*, which is a three-armed plate with a conical center in which a tapered hole is formed to receive the tapered end of the spindle *b*. In the case of portable spindles, the arm and the spindle are usually fastened tightly together and the spindle is rotated in the hole in the centering plate or guide. When the spindle is not to be turned, a key *c* is used, that is fitted so well in the tapered seat that the spindle cannot be moved sidewise. The plate *a* is held firmly by stakes driven through the holes *d*, or it may be bolted to a bottom plate. The key should be driven in lightly, so that it can be removed by hand. A stationary spindle needs no shank at the lower end. It is simply rounded so as to fit a similar hollow in the center of the spindle seat, as shown in Fig. 16. The diameter

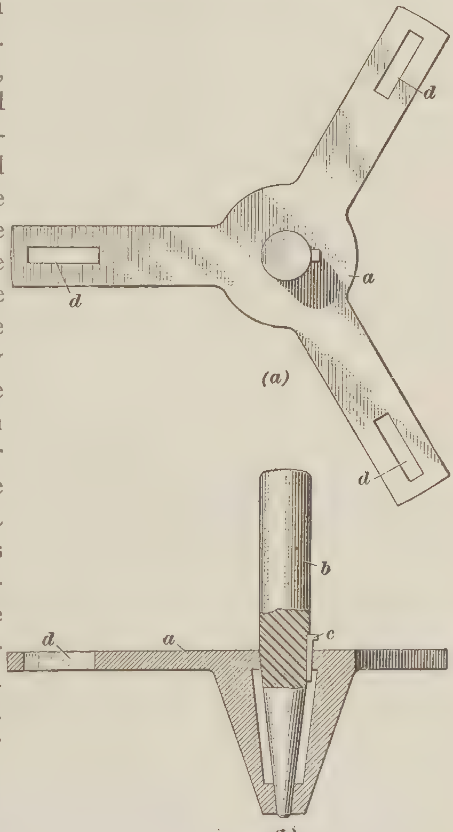


Fig. 17

of the spindle sometimes is governed by the nature of the work. Large portable spindles are preferably made tubular and 6 inches in diameter, as they are supported only at the lower ends. If they were of small diameter, they would be bent by the use of large, heavy sweeps of great radius. Stationary spindles are usually made 3 inches in diameter. For ordinary work up to 6-foot radius, 3-inch spindles are safe.

49. Spindle Arms.—The spindle arm, which is the part to which the sweep is bolted, may be of steel or cast iron; also, it may be fixed to the spindle so as to turn with it, or it may swing around on the spindle. In Fig. 16 the arm *d* is supported by two bearings *e* and *f* that fit around the spindle *a*. The brace *g* takes the downward pull of the arm and prevents it from sagging. The collars *h* and *i* are held firmly to the spindle by setscrews and prevent the arm from working up or down, while at the same time allowing it to swing. The sweep is bolted to the arm *d* by the bolts shown in the slots. The slots are made long so that the sweep may be adjusted readily.

DETAILS OF LOAM WORK

50. Laying Bricks.—Molding in loam demands some skill in bricklaying, as a loam molder must often build difficult constructions of brickwork. To make the brickwork strong enough to resist the pressure of the metal during pouring, the bricks must be laid in such a way as to tie the layers, or courses, together. In Fig. 18 (*a*), for example, the bricks *7* and *8* are laid so as to cover the joints between the bricks *9*, *10*, and *11*, which in turn cover the joints between the bricks *12*, *13*, *14*, and *15*. This method of arranging the bricks is called *breaking joints*, and it prevents the brickwork from pulling apart lengthwise. To bind it crosswise, a row of *headers*, or bricks laid lengthwise across the others, is used, as indicated by the bricks *2*, *3*, *4*, and *5*. A course of headers is used to every 4 or 5 courses of bricks laid lengthwise. In (*b*), which is a top view of a 12-inch wall, the bricks numbered from *1* to *21* are headers.

51. Thickness of Loam on Mold.—The facing of loam on the brickwork may vary from $\frac{1}{4}$ to $\frac{3}{4}$ inch; that is, the face of the brickwork should not be closer than $\frac{1}{4}$ inch to the cutting edge of the sweep nor more than $\frac{3}{4}$ inch away from it. The greater distance is allowable when the casting is very thin. The layer of loam should not be any thicker than is necessary. If not made deep, it can be put on more easily and quickly and it will dry more rapidly, so that less time will be wasted in waiting for it to set and stiffen. It should be of such consistency as to stick firmly to the brickwork without showing

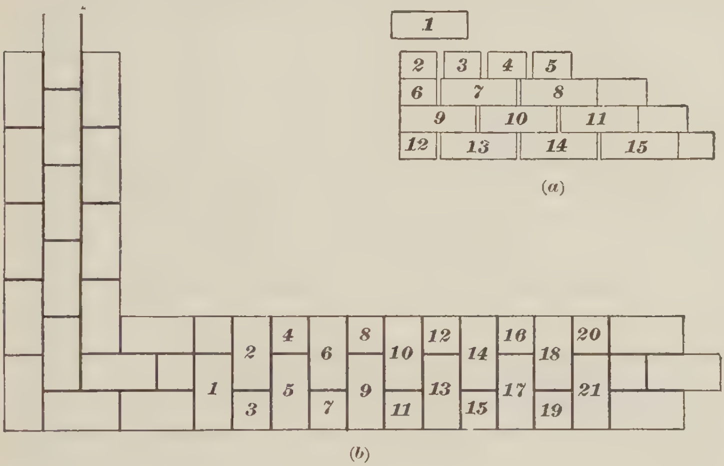


FIG. 18

any tendency to sag on the face of the mold. Sagging seldom occurs when the loam is less than $\frac{3}{4}$ inch thick, but it is liable to happen with greater thicknesses. When great thicknesses cannot be avoided, the loam should be as stiff as possible and should be well rubbed in by the hand on the face of the bricks.

52. Shaping Loam With Sweep.—Loam should be rubbed on quickly with the hands, the object being to obtain a large section that can be kept soft until the cutting edge of the sweep has been passed over it. If it is kept soft, the sweep will leave it smooth, without tearing it, and the finishing coat of loam can then be applied easily. It may be necessary

to pass the sweep over the rough loam several times before it is smooth enough. Before using the sweep, all holes should be filled up as smoothly as possible with the hands. The cutting edge of the sweep should be kept clean and free from stiff loam and grit. There is no fixed rule as to the direction in which the sweep must move, but it is usually rotated in the same direction as the hands of a watch. If the molder can work more easily and rapidly by turning it in the opposite direction, this plan should be followed. The cutting edge of the sweep must then be changed to the opposite side.

53. Before starting to put on the finishing coat, the rough, coarse loam should be swept up as full as possible. This work is made easier by having the coarse-loam mixture thin when evening up the rough loam of the last sweeping. The coarse under coat should be dried until it is stiff and hard, so that the moisture from the finishing coat may be absorbed fairly rapidly. The finishing coat should be put on so evenly that one revolution of the sweep will suffice. If more are made, the face will rarely be as smooth as if only one revolution were made.

54. Finishing Loam Molds.—The amount of finishing with the small tools required by a mold depends on how smoothly it has been swept up and how smoothly the building up around the patterns has been done. A mold should be swept up so smooth as to require no tool finishing, as blacking scabs will thus be prevented. Slicking the loam surface of a mold helps to close up the pores and prevent the escape of the gases, thus tending to form scabs and buckles. More or less finishing is generally necessary where patterns are used, as at the brick joints there may be seams that should be cleaned out and filled in with fresh loam. Then, again, the oil that is used on the pattern to prevent the soft loam from sticking to it must be washed off, so as to avoid forming a parting and causing the blacking to peel off.

55. In starting to finish parts of a mold that have peeled off, or those roughly swept, a wad of waste or hemp, or

preferably a 4-inch paint brush, is saturated with water and rubbed over the face of the mold. Thin finishing loam is then rubbed over the wet surface with the hand or the brush. A hardwood smoothing block, about 2 inches thick by 4 inches wide and 8 inches long, having rounded edges, so as not to tear the mold, is rubbed over this. The action of the smoothing block should leave the face of the mold in such a condition that a little slicking with the finishing tools will make it ready for blackening.

56. Blackening Loam Molds.—The blackening of a loam mold should be done before the surface becomes too dry; otherwise, the blacking dries so rapidly that it is difficult to do good smooth finishing. As a rule, loam molds cause the blacking to stiffen very rapidly. In such a case, only a small section at a time should be blackened in order that it may not stiffen too much before being finished with the slicking tools. Loam molds are blackened either green or dry, as are dry-sand molds, but blackening while green is the usual and the best practice. The thickness of blacking required depends on the proportions of the casting. The character of the blacking mixtures is practically the same as for dry-sand work, as is also the use of tools in finishing. Too much slicking of the blacking should be avoided. If it is put on with a sprayer, better results are obtained by going over it with a wet paint brush.

EXAMPLES OF LOAM WORK

LOAM MOLD FOR PLAIN CYLINDER

57. Preparation of Rigging.—Perhaps the most important part of the work of making a loam mold is the preparation of the rigging. The rigging is a term used to denote the devices or apparatus required in the making of the mold and includes rings, plates, beams, slings, bolts, etc. The plates and rings for the particular work to be done are cast before the mold is begun and serious delay will result if they are made too

large or too small. Therefore, the pattern sizes of the pieces of rigging that must be made should be calculated and marked on the drawing, or on rough sketches of the pieces. The dimensioned sketches can then be used as working drawings when the pieces are being laid out on the open sand bed. Many intricate jobs require drawback plates, which cannot well be made until the mold is built up to the point at which they are to be used, and templets must sometimes be constructed for the purpose of making these plates correctly; but the main part of the rigging should be made from the dimensioned sketches.

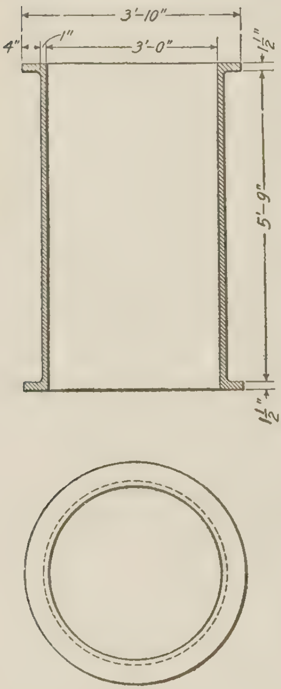


Fig. 19

58. Bottom Plate.—To illustrate the method of making a loam mold, it will be assumed that a plain flanged cylinder of the form and dimensions shown in Fig. 19 is to be cast. The mold is to be self-contained; that is, all the necessary parts are to be bolted together, without using a cross or a beam of any kind. The first step is to prepare the rigging for the job. A bottom plate must be made, of sufficient diameter to carry the outside wall or cope of the mold, whether it is lifted away or left stationary. The outside diameter must be equal to the greatest diameter of the casting plus twice the thickness of the wall plus twice the shrinkage of the plate. Double shrinkage is added because shrinkage occurs in casting both the plate and the cylinder. Except in the case of very large plates, the shrinkage need not be figured closely, but may be taken as $\frac{1}{8}$ inch per foot. In the example given, the diameter of the casting over the flange is 46 inches. The wall will be 9 inches thick. The diameter of the casting plus twice the wall thickness is therefore $46+(2\times 9)=64$ inches, or

5 feet 4 inches. If the shrinkage is $\frac{1}{8}$ inch per foot, in 5 feet 4 inches it will be approximately $5 \times \frac{1}{8} = \frac{5}{8}$ inch, and the double shrinkage will be $2 \times \frac{5}{8} = 1\frac{1}{4}$ inches. The outside diameter, representing the pattern size of the bottom plate, is therefore 5 feet 4 inches plus $1\frac{1}{4}$ inches, or about 5 feet $5\frac{1}{4}$ inches, as shown on the sketch, Fig. 20.

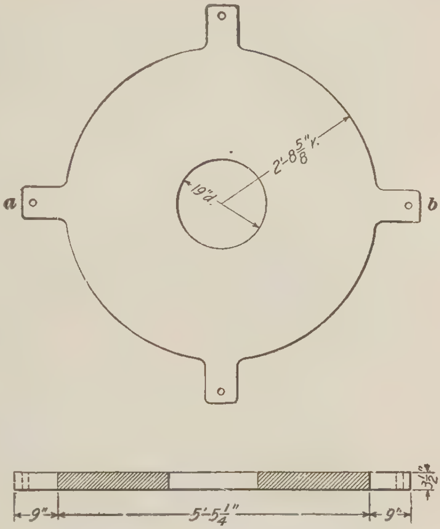


FIG. 20

59. Cope Ring. There are different ways in which the mold may be constructed. The core may be built on the center of the bottom plate and the cope on a ring lying on the bottom plate, so that the cope can be lifted away from the core. Again, the cope may be built on the bottom plate and the core on a separate plate, so that it can be lifted out of the cope. In making the mold for the plain cylinder, the first method will be followed. This necessitates the preparation of a cope ring on which the outer wall may be built and by which the cope may be lifted off the bottom plate. The outside diameter of the cope ring, as shown in Fig. 21, is the same as that of the bottom plate, and

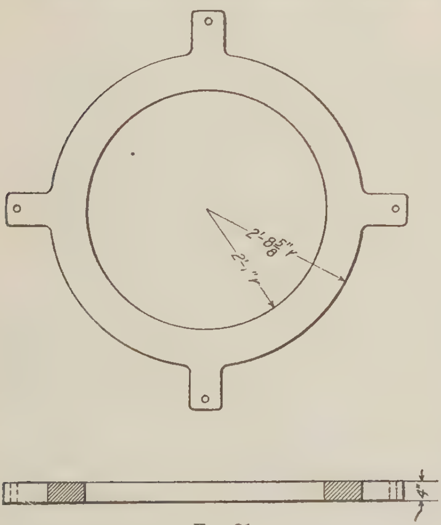


FIG. 21

the inside diameter is such that there will be about ½ inch of clearance between the ring and the bottom seat. The bottom seat is the first part of the mold that is made and is built on the bottom plate, as will be explained later. The cope ring is made with four lugs for the lifting rods and is about 4 inches thick.

60. Top Plate.—After the cope and the core are made and assembled, the top of the mold is covered with a top plate, which is a cast-iron plate having prickers to hold the loam that is swept up on its surface. Two methods of preparing the top plate are shown in Fig. 22. The prickers may consist of a number of short fingers *a* projecting from the surface of the plate. The loam *b* is then swept over these and is held by them. Usually, straws *c* are laid next the plate, before the loam is applied, so as to assist in venting the mold. The top plate, of course, is turned upside down, with the prickers uppermost, when the loam is applied. Another way is to make the prickers long and wide, as at *d*, and to lay bricks *e* between them before adding the facing of loam *f*.

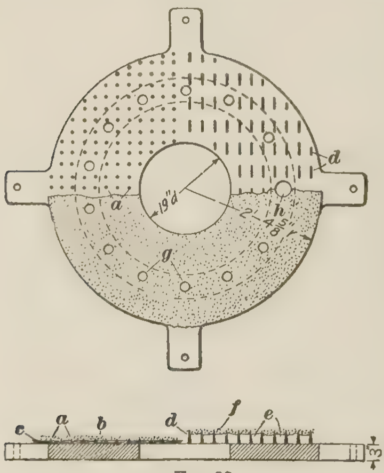


FIG. 22

The first method is the quicker and should be used if but one casting is to be made. But if a number of castings are to be made from the same mold, or the area exposed to hot metal is great, the second method is preferable, as the top is not so likely to draw down. A little patching after each pouring prepares the plate for another casting. The outside diameter is made 8 inches less than the diameter of the bottom plate, as the brickwork is 8 inches less at the top of the mold, and the inside diameter is equal to that of the inside of the bottom plate, or the inside of the core. Gates *g* for top pouring are cast in the top plate, as well as a riser *h*.

61. Bottom Seat.—The first step in the construction of the mold is to set the spindle seat firmly and to fit the spindle *a*, Fig. 23, taking care to have it plumb. The spindle

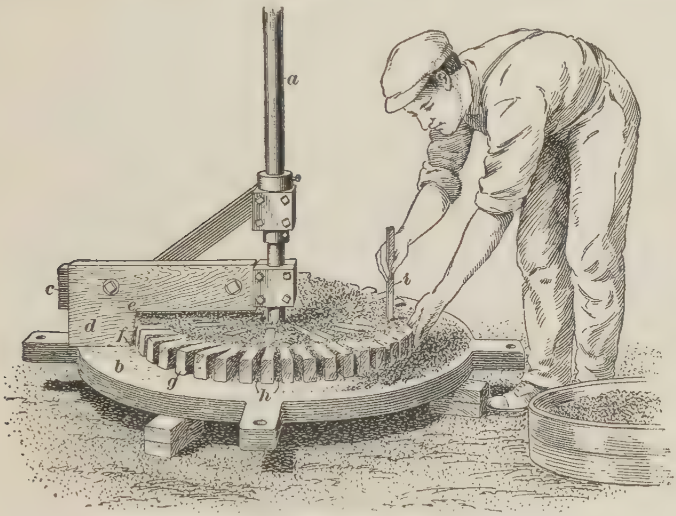


Fig. 23

is then removed and the bottom plate *b* is set level on the floor or on bearings, with the spindle seat approximately central with the plate. The spindle is replaced and the sweep arm *c* and the sweep *d* are put on and adjusted to give the required diameter. The point *e* should be 23 inches from the center of the spindle, so that it will sweep a circle 46 inches in diameter, equal to the diameter of the flange of the cylinder. The point *f* should be 1 inch farther from the center of the spindle so as to give a slope to the parting of the mold, and enable the cope to be lifted away easily. The sweep is adjusted by the aid of a size stick, or gauge, like that shown in Fig. 24.

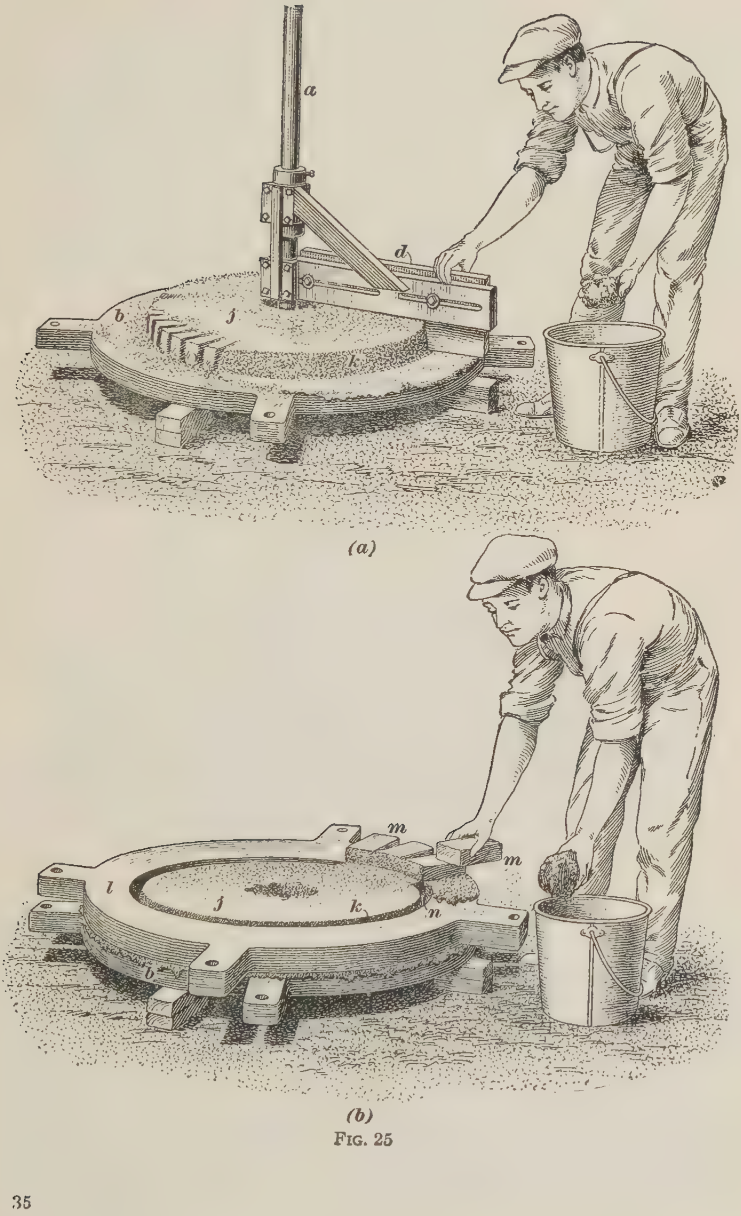
Fig. 24

It consists of a wooden bar with one straight edge *a* and having at one end a semicircular notch *b* that fits exactly over the spindle. A mark *c* square with the edge *a* denotes the center *d* of the spindle and the desired distance is laid off on the edge *a*

and marked by a line, as *e*, to which the cutting edge of the sweep must be set. The point *f* is usually the outside of the casting and the point *e* the inside.

62. After the sweep has been adjusted, bricks *g*, Fig. 23, are laid on edge in a mortar of mud, and in a circle so that the outer ends are not less than $\frac{1}{4}$ inch from the cutting edge of the sweep at the point *e*. Openings will be formed between the bricks, as at *h*, due partly to the impossibility of making flush joints with rectangular bricks and partly to the necessity of having openings between the joints to act as vents for the steam and gases. The spaces between the bricks are filled with cinders rammed in snugly with the end of a file or flat piece of iron *i*, because no voids must be left between the bricks, in loam work; if they are, pockets of gas will be formed. This method of venting brickwork is much used in loam molding. The cinders needed are obtained by using $\frac{1}{4}$-inch and $\frac{1}{2}$-inch riddles. When the spaces have been packed with cinders, the outer ends and upper faces of the bricks are brushed clean and free of cinders and a coarse loam mixture is daubed over them and swept up, as shown in Fig. 25 (*a*). A fine finishing coat of loam is then put on and swept up until the whole foundation *j* has the appearance of the part just under the sweep *d*.

63. Construction of Cope.—After the foundation *j*, Fig. 25 (*a*), has been finished, it is hardened by a fire or by a torch and a parting is made on the sloping surface *k*, by brushing on a coat of heavy machine oil and rubbing parting sand on it. The sweep and the spindle are removed, as in (*b*), and the cope ring *l* is put on, care being taken to have its lugs to one side of the lugs on the bottom plate *b* and not directly over them. Bricks *m* are now laid in loam on the upper surface of the cope ring, and in this row is set the bottom pouring gate, tangent to the circular top of the foundation *j*, so that the metal will have a rotary motion when entering the mold. While these bricks are being laid, loam is rubbed on their inner ends and their under surfaces and they are pushed inwards against the sloping surface *k*. The loam thus



(b)

FIG. 25

fills the space *n* between the cope ring *l* and the parting *k*. Before this row is finished, the wooden pattern for the lower flange is laid on the surface of the foundation *j*, with its outer edge in line with the circular edge of the foundation. The flange is well coated with oil before it is set in place, so that loam will not stick to it. All patterns used in loam work should be treated in this way. The flange pattern may be set true by going around the inside of it with the sweep, or by drawing a circle on the surface of the foundation *j* and setting the pattern to that.

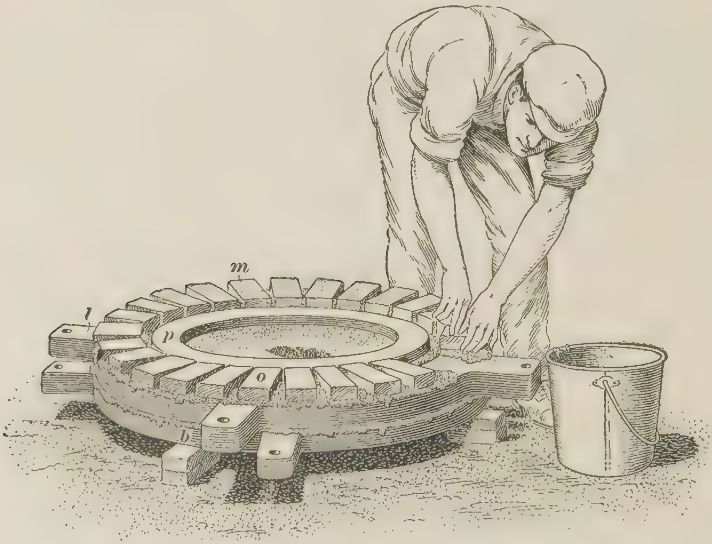


Fig. 26

64. The appearance of the mold, with the flange pattern in place and the layer of bricks on the cope ring almost completed, is shown in Fig. 26. The upper surface *o* of the row of bricks *m* is slightly higher than the upper surface *p* of the flange pattern. The space between the ends of the bricks and the outer edge of the flange pattern is now filled with loam, and the top surface *p* of the oiled pattern is covered with loam. Then, as shown in Fig. 27, a layer of bricks *q* is laid on the surface *o* of the bricks *m*. Loam is rubbed on

the under faces of the bricks q and they are pressed down firmly on the surface p of the flange pattern. The inner ends of the bricks in the course q should be not less than $1\frac{1}{4}$ inches from the inner edge of the flange pattern, so that when the inside surface of the cope wall r is covered with loam and swept up, it will be outside the inner edge of the flange pattern just 1 inch, or the thickness of the metal in the cylinder wall. The wall of the cope is then built up, as shown, by adding courses, making every fourth or fifth a course of headers,

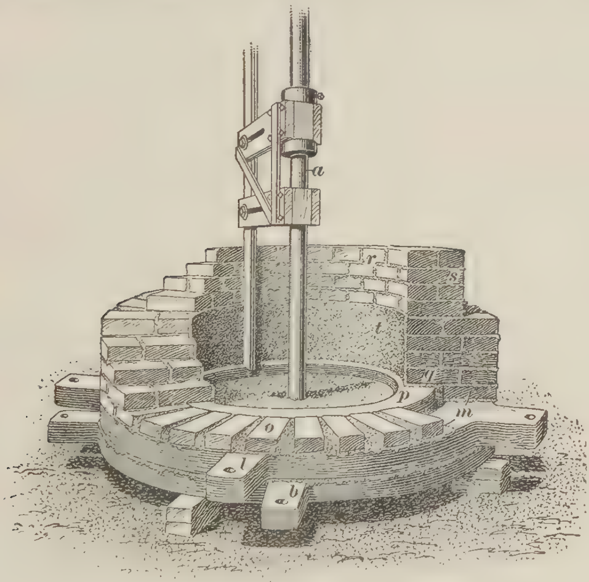


FIG. 27

as at s. After five or six courses have been laid, counting from the bottom plate, the wall may be reduced to a thickness of 9 inches, or to the length of one brick. No cinders or other venting materials are used in a wall of this kind. The mud and loam used should be porous enough to permit the escape of a small amount of gas.

65. In the case of a large cylinder, the whole cope may be built up before any loam is applied to the inner face; but the cylinder selected as an example has an inside diameter

of only 36 inches, which is not great enough to allow a man to work conveniently inside with the sweep. After 1 foot or 18 inches of cope wall has been built, therefore, it should be faced with loam, as at *t*, Fig. 27, and swept up to a diameter of 38 inches inside. Then another section of from 12 to 18 inches should be built and similarly swept up, until the cope is finished. The flange at the top is swept up by using a block of the correct dimensions fastened to the sweep arm. Just above it a straight sweep is attached, to form the flat surface for the joint at the top of the cope. When the cope is completed, it is lifted off the bottom seat by slings attached to the cope ring *l* and then is blackened and finished on the floor. The bottom joint is marked before the cope is lifted away.

66. Marking Cope for Resetting.—After the cope wall has been finished, a circle is drawn on top of it by using the sweep, and this is divided into four equal parts, plain marks being made at the four dividing points. The top plate is set correctly by these marks when the mold is

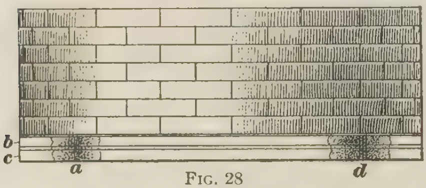


Fig. 28

to be closed. As the cope must be lifted off the bottom plate until the core is built up, the cope ring and the bottom plate must be marked plainly, so that they can be put together again in exactly the same relative positions that they occupied while the cope was being built. One way of doing this is shown in Fig. 28. Before the cope has been lifted off, it is necessary to daub on some fine mud, about $\frac{1}{8}$ inch thick, made of new molding sand, and on each patch so daubed to make marks or cuts with the trowel, as at *a*, extending across the joint between the cope ring *b* and the bottom plate *c* and showing on the edge of each. At another point *d* three such marks should be made and at a point on the opposite side, four such marks. After the parts of the mold have been dried, they may be put together again in the correct positions by adjusting the cope until the marks match, as when they were first made.

67. Construction of Core.—The removal of the cope leaves only the bottom seat, or foundation, resting on the bottom plate. The core must be built on top of this seat. The spindle and the sweep are first set and adjusted, as shown in Fig. 29. The inner, or cutting, edge of the sweep *b* is set so as to sweep a circle 36 inches in diameter, and then a wall is built, as at *f*, Fig. 30, with the outer face about $\frac{1}{4}$ inch from the cutting edge of the sweep. Broken bricks, or bats, should be used for this wall, as they will conform to the circular

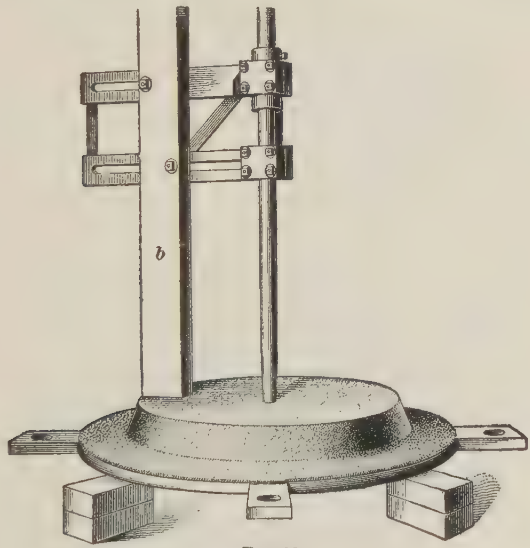


FIG. 29

shape better than whole bricks. After the bottom has been built up four or five courses high, it is daubed with loam and swept up to the finished size, as shown in Fig. 31, which also shows the molder daubing on the last coat. The core being finished thus far and the loam having stiffened at the base *c*, courses of half-bricks are continued, as described, until the top is reached, and the remainder of the core is daubed and swept. Bricks should not be laid too close in building cores; instead, plenty of mud should be used between them. In narrow pockets that are hard or unsafe to vent with cinders or

straws, the best and most modern way is to lay wax wires where the vents should be and build them in. When the mold is dry the wax will be absorbed in the building material and a free and clean vent will be left.

68. Sweeping Loam on Top Plate.—When the cope and the core have been finished, the only part of the mold remaining to be made is the top plate. The plate is set on bearings, in the same way as the bottom plate, but with the pricker side up. The spindle and the sweep are then set and the sweep is adjusted so as to swing about $\frac{3}{8}$ inch above

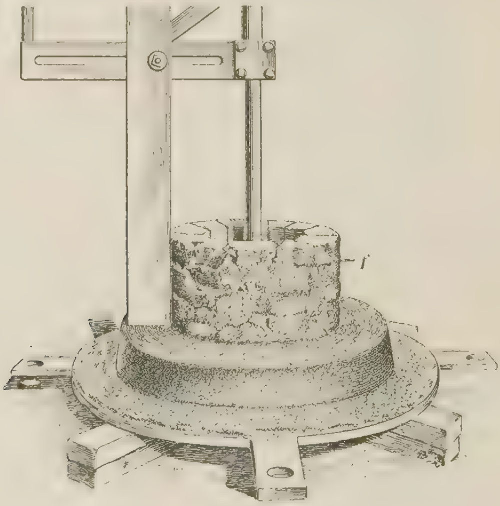


FIG. 30

the tips of the prickers. Assuming that the form of construction shown in the left half of Fig. 22 is to be used, straws are laid among the prickers, against the plate, and loam is added in an even layer. A finishing coat of fine loam is rubbed on with the hands and swept up to a level surface with the sweep. Holes having been previously cast in the top plate for gates and riser, two circles must be drawn with the sweep, one equal to the outside and one equal to the inside diameter of the cylinder casting, and between these two lines the gates must be set. They should not in any case be more than

half the width of the casting and great care must be taken to place them in the center between the two circles; for if the stream of metal that flows through them strikes either side wall, the surface is liable to be cut or washed away, and a bad or dirty casting will be the result. Two diameters are drawn at right angles to each other on the face of the loam

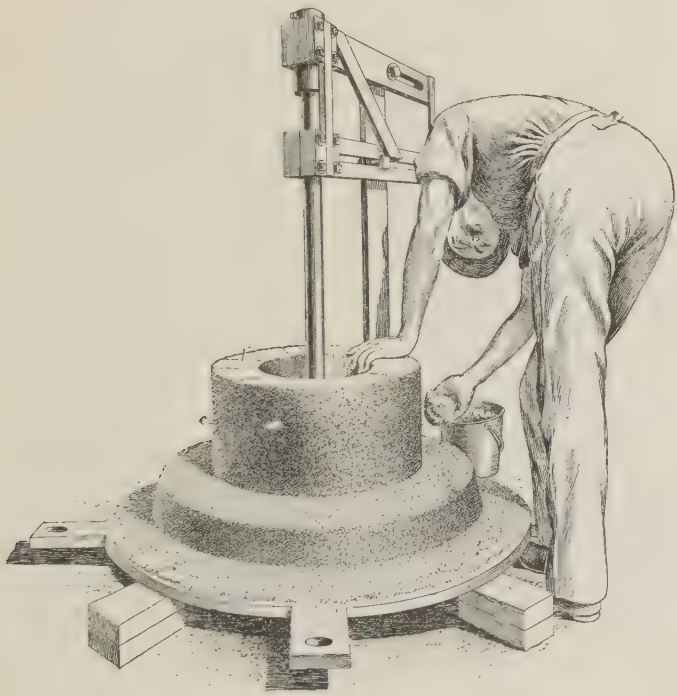


FIG. 31

on the top plate and their outer ends are marked plainly with the trowel. These marks are used in locating the top plate correctly on the cope. The marks on the top of the cope and on the top plate must be made in such positions that the lugs on the top plate will lie directly above those on the bottom plate, in order that the bolts by which the mold is held together may run straight up and down.

69. Closing Mold for Cylinder.—After the several parts of the mold have been dried, the mold is assembled by putting the parts together in their correct relative positions. This is made easy by the marks scratched on the different parts before they were taken apart. The cope is lowered over the core until the ring rests on the bottom plate, with the marks on the edges of both plates matching in the same positions as when they were made. Next, the top plate is set on, with the loam surface down. The four marks on the

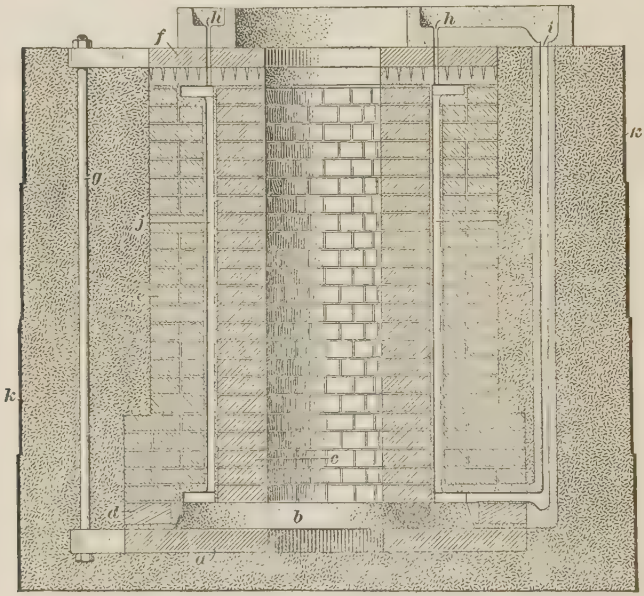


FIG. 32

outer edge of the top plate are made to match the four marks scratched on the top surface of the cope, and the top plate is then in its correct position. Dough rolls or paste must be used on all joints between parts of the mold, as in dry-sand work

70. Securing Mold for Cylinder.—A vertical section through the mold after it is closed is shown in Fig. 32. The bottom plate *a* supports the bottom seat *b* on which is built the core *c*. The cope ring *d* rests on the bottom ring and

carries the cope *e*. The top plate *f* covers the upper ends of the core and cope and the mold is secured by bolts passing through the lugs on the top plate and the bottom plate. One of these bolts is shown in place at *g*. Links, hooks, and turnbuckles may be used instead of long bolts, if desired, the turnbuckles serving to tighten the links; or, beams or crosses may be laid across the top of the mold and tied down firmly to eyebolts securely bedded in the floor. Oftentimes molds are weighted down by placing heavy blocks of iron on the tops. Any one of these methods can be used, but that shown is simple and safe and can be applied in almost any place and to a wide range of work.

71. Gating Mold for Cylinder.—Deep cylinders and other deep castings are usually gated at both the top and the bottom. The sectional view, Fig. 32, shows two of the top gates at *h* and the bottom gate at *i*. The top gates, as stated in Art. **68**, are set central above the space *j* representing the wall of the cylinder. The bottom gate, as stated in Art. **63**, is set so that the metal enters the mold tangentially. Iron is usually allowed to enter the mold first through the bottom gate; for if it were poured at first through the top gates, the bottom of the mold would be apt to be cut where the iron fell. When pouring through the bottom gate first, the metal is allowed to rise a few inches in the mold, and then the ladle is turned so as to fill the runner and so cause the iron to flow through the top gates also. Top pouring is usually the cleanest method and should be used whenever possible.

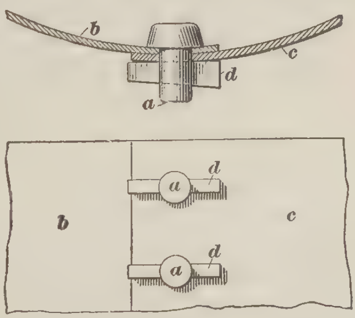


FIG. 33

72. Curbing.—In addition to securing the mold as just described, provision must be made to prevent bursting. This is done by building curbing around the mold, as shown at *k*, Fig. 32, and ramming sand between it and the mold. The

curbing consists of $\frac{1}{4}$-inch steel boiler plates with 2-inch holes drilled near their ends, so that they can be fastened end to end to form a ring. Bolts should not be used for this purpose, as the nuts will rust fast and be difficult to remove. Instead, cast-iron pins should be used, as shown in Fig. 33. The pins *a* are put through the holes in the plates *b* and *c* and keys *d* are driven into slots in the pins, thus binding the plates firmly. When the curbing is to be taken down, the keys

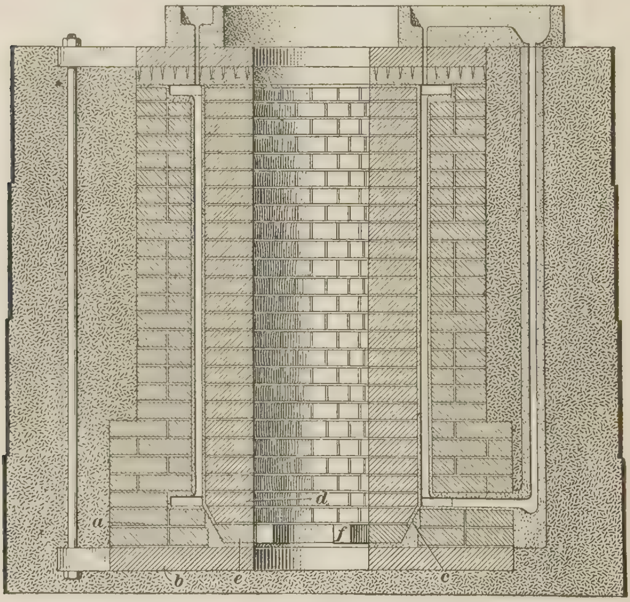


FIG. 34

are knocked out, the pins driven back into the sand, and the plates removed. The curbing is built up in rings, each of which fits just inside the top of the one below it. Curbing of the type shown in Fig. 32 is necessary only when the mold is assembled above the floor level or in a pit too large for it. If it is set in a casting pit of the right size, dug in the floor, the backing sand is rammed in between the sides of the pit and the mold, thus preventing the mold from bursting. Either method may be used, and one is as safe as the other, if good

curbing is employed. Casting above the floor has the advantage that when the casting is cool enough the mold may be knocked apart and the casting taken out quickly; whereas, if the mold is in a pit, the casting must be dug out. The backing sand must be rammed hard and should be put in in courses not more than 6 inches deep. The distance between the mold and the curbing at the bottom depends on the height of the mold, as each ring of curbing is set inside the one below it. If all the ramming is done by hand, from 4 to 8 men are needed. The leader takes the peen end of the rammer to ram around close to the mold walls and goes roughly over the surface between the mold and the sides of the pit, and he is followed by his helpers with butt rammers. The bottom course should be rammed very solidly, so as to prevent straining.

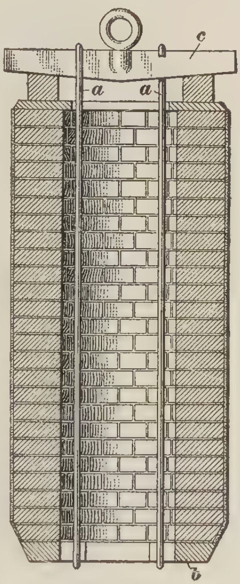


FIG. 35

73. Mold With Loose Core.—If the mold for the cylinder had been made with a removable core, no cope ring would have been necessary, but a lifting ring for the core would have been required. The mold would then have been constructed as shown by the section in Fig. 34. The foundation *a* is built directly on the bottom plate *b* and has an inclined seat *c* against which the lower end of the core *d* fits snugly. The core is built on a lifting ring *e* that fits in the seat at the center of the bottom plate and that has lugs *f* on the inside by which the core can be lifted out. In this case, the foundation is built first, and the parting made at *c*, after which the core is swept up. The core is then lifted out and the cope is built as already described. The remaining details of construction are the same as in Fig. 32. When the core is lifted, the arrangement shown in Fig. 35 is used. Rods *a* with hooks at their ends are passed through the lugs on the lifting ring *b* and over the arms of the cross *c*, which has an

eyebolt at the top. A plate is laid on the top of the core and wedges are driven between it and the cross, thus binding the core firmly. The lifting ring has the form shown in Fig. 36.

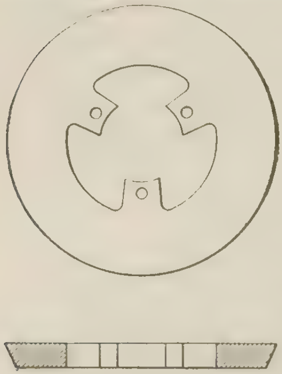


FIG. 36

LOAM MOLD FOR LARGE WHEEL

74. Making Castings in Parts. Sometimes it is necessary to make a casting in two or more parts that are afterwards machined and bolted together to form the desired piece. An example of this kind of work is casting a large wheel in two parts that, when properly machined and put together, will form a true circular piece. There are various reasons for making castings in parts, such as safety of design, ease of transportation, and convenience in handling the finished work. One of the oldest methods of sweeping up a mold for a two-part casting was to use two spindle seats and spindles, when the distance between the spindle seats was sufficient to enable the work to be done. An eccentric was used as an improvement on the two-seat method; but it had the disadvantage of having to be swung around on the spindle after one-half of the mold had been swept up.

75. Cam Arrangement for Sweeps.—An improvement on the eccentric and the double seat is the double-cam fixture shown in Fig. 37. It consists of a base plate *a* to which the strips *b* and *c* are riveted, forming a groove *d* of uniform width. The opposite halves of the groove have the same size and shape and are parts of a circle somewhat greater than a semicircle. The centers of the two parts are at *e* and *f*, and the distance between these centers is usually 4 inches. Above the base plate an arm *g* is so fitted to the spindle *h* that it can be swung around the spindle. It is prevented from moving downwards by the hub *i* of the cam, which is held to the spindle by a setscrew. The arm *g* has machined slides

in which the end of a movable arm *j* has a sliding fit. A bracket *k* cast on the inner end of the arm *j* carries a steel roller *l* that fits snugly into the groove *d* of the cam. The spindle must not move when the device is in use and is therefore held in the base-plate hub by a key.

76. When the arm *g*, Fig. 37, is swung around the spindle, the roller follows the groove in the cam and the arm *j* is moved

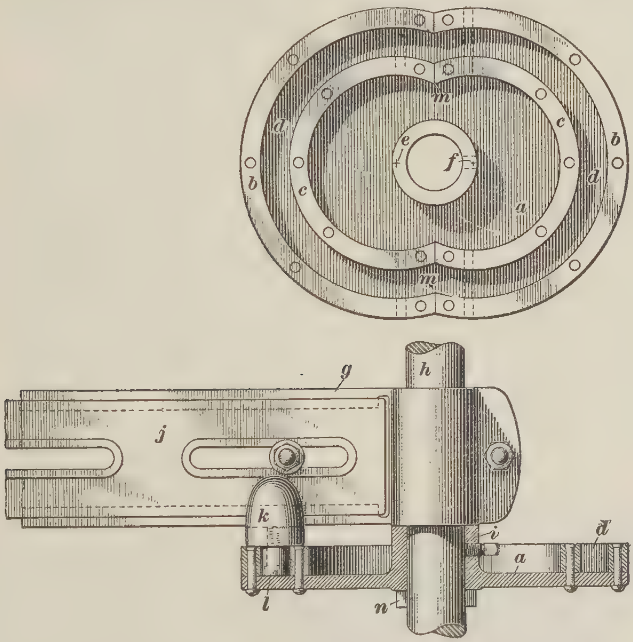


Fig. 37

in or out along the arm *g*. The sweep is bolted to the outer end of the arm *j* and one-half of the mold is swept up while the roller moves through one-half of the groove. The two arms are slotted and bolts with washers are passed through the slots, preventing the arms from coming apart, yet allowing endwise movement. The end of the sweep is not given a true circular movement; but the device is accurate enough for all practical purposes. The sweep is set with size sticks in the usual way; but it must be directly over one of the

points m when the setting is made, or the mold will be too large. Lugs n are cast on the under face of the base plate and machined on the surfaces farthest from the spindle. A straightedge laid along these faces from one side to the other will pass directly across the centers e and f. As the centers are 4 inches apart and a splitting core 3 inches wide is generally used, each half of the casting will have $\frac{1}{2}$ inch for machining and finishing on the surfaces that are to come together.

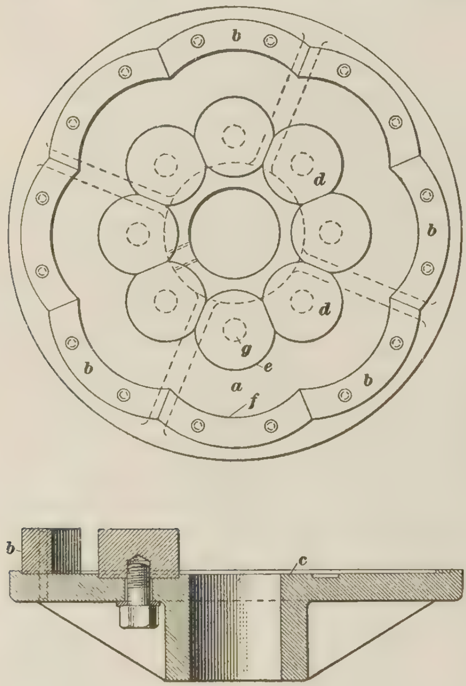


FIG. 38

77. Another cam, for sweeping up a wheel in eight segments, is shown in Fig. 38. The outer face of the groove a is formed by a series of eight curved strips b riveted to the base plate c, and the inner face by eight circular blocks d bolted to the base plate. The outer surface e of each block and the inner surface f of each strip have the same center g, which is the center of the block. The distance between them is equal to the diameter of the roller that runs in the groove. The same swinging and sliding arms are used with this cam as with the one shown in Fig. 37. The same principle may be used in making a cam to sweep squares, pentagons, hexagons, ellipses, and so on.

78. Building Inner Part of Mold.—Large wheels can be made truer to size and more cheaply in molds swept up

in loam than by any other method, and the requirements in the way of patterns are few and simple. The casting is still further simplified if it is done above the floor level instead of in a pit. The spindle seat is firmly bedded in the floor and the spindle is set plumb. Then a sweep

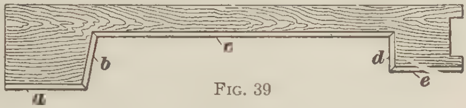


Fig. 39

of the form shown in Fig. 39 is made, with the cutting edges at *a*, *b*, *c*, *d*, and *e*, and a bed of sand well rammed is swept up to form a seat for the hub and arm cores. The bed thus swept up is shown in Fig. 40. The surface *a* is shaped by the cutting edge *c* of the sweep in Fig. 39, and the cutting edges *a* and *b* of the sweep form that part of the bed between *b* and *c*, Fig. 40. On the level outside circle swept up by the cutting edge *a*, Fig. 39, is built the wall *d*, Fig. 40, on which loam is swept up to the shape of the inside surface of the rim of the wheel. On the surface swept up at the center by the edge *e*, Fig. 39, are laid the halves of the dry-sand core in which the lower end of the hub is formed. The construction of the core box for these cores is explained later. This wheel is cast in two parts, and so the sweep *e*, Fig. 40, for forming the mold for

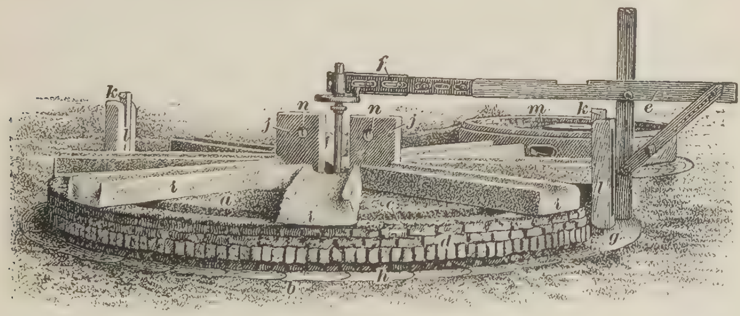


Fig. 40

the hub is attached to a double-cam device *f* similar to that illustrated in Fig. 37.

79. The surface *g*, Fig. 40, corresponds to one side face of the rim, and if it is simply swept up in loam and skin-dried,

scabs are apt to occur in the casting. To prevent this, the sweep is made so as to form the surface *g* about $1\frac{1}{2}$ inches too low. Then flat cores $1\frac{1}{2}$ inches thick, as shown at *h*, are laid in a circle at the base of the wall *d*. These cores, as shown in Fig. 41, are about 1 foot long and 8 inches wide and are made with semicircular ends, so that they can be fitted together to form circles of different sizes. The eight bottom half cores *i*, Fig. 40, for the arms of the wheel are next laid in position, as shown, so that when the loam is swept up on the wall *d* it will come flush with the outer ends of these cores. The splitting cores *j* at the hub and the prints *k* for those at the rim are set in line between the halves of the mold and also midway between two arms on each side. The print *k* for the splitting core at the rim is made in one piece with the pattern *l* for forming the flanges on the inside of the rim.

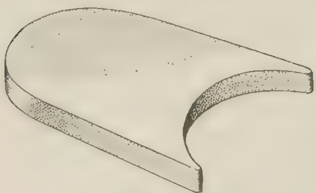


Fig. 41

The top halves of the cores for the arms are set on the lower halves *i* and the wall *d* is covered with loam and swept up. When this is done, the mold has the appearance of the one shown at *m*.

80. Cores for Hub and Rim Bolts.—The two parts of the casting are joined together by bolts at the hub and at the rim. The holes for the hub bolts are formed by cores put through holes in the splitting cores *j*, Fig. 40. Two of the four holes are shown at *n*, the other two being at the lower ends of the splitting cores. The bolt-hole cores are supported at their ends by the hub core. Each of the rim joints is made with the necessary number of bolts, which pass through flanges cast on the inner face of the rim. The sides of the pattern *l* form these flanges. In the case of the wheel shown, no cores were used for bolt holes at the rim, as these holes were drilled. But if it had been desired to use cores, prints would have been attached to the sides of the pattern *l* and the cores would have been set in after the pattern had been removed. After the center of the wheel has been swept up, the print *k* and the pattern *l* are drawn out.

81. It is not necessary to use a pattern *l*, Fig. 40, to form the flanges at the rim. The usual way is to make a core and build it in at the end of the half of the rim. A wheel mold made in this way is shown in Fig. 42. The core for the flanges

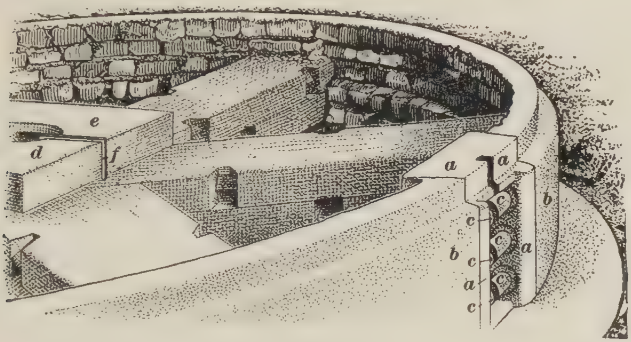


FIG. 42

at the ends of the halves of the rim is shown at *a*, built up with the wall *b*. Each half of the core carries three cores *c* for the bolt holes in the flanges. These cores are held in prints formed in the core *a* and their ends are separated by a distance equal to the thickness of the splitting core that is later set between them. The core *a* is formed in the core box shown in Fig. 43 (*a*) and (*b*). The parts *a* form the flanges and the part *b* forms the print for the splitting core. The pins *c* inserted through holes in the sides of the core box are withdrawn before the core is removed, and leave the holes in which the bolt-hole cores are afterwards inserted. The sand core occupies the space *d*.

(*a*) FIG. 43 (*b*)

82. Building Outside of Mold.—While the inside of the mold is being made, the outside may be built on another part of the floor. The outside consists of a circular wall with its inner face plumb and of a height equal to the width of the rim of the wheel. It is built on a lifting ring of suitable

diameter and its inner surface is swept up with loam to the correct diameter of the wheel. The lifting ring is included in the height of the wall; therefore, its inner face is made with short prickers to hold about $1\frac{1}{2}$ inches of loam. Brick spalls and chips are placed between the prickers to absorb moisture from the loam and thus cause it to stiffen more quickly. Both parts of the mold are dried overnight by one of the usual methods of drying mentioned in connection with dry-sand work. The appearance of the outside wall is shown in Fig. 44. The wall *a* is supported by the lifting ring *b* and the whole is suspended by chains from an overhead crane, ready to be lowered over the inner part of the mold, shown at *c*.

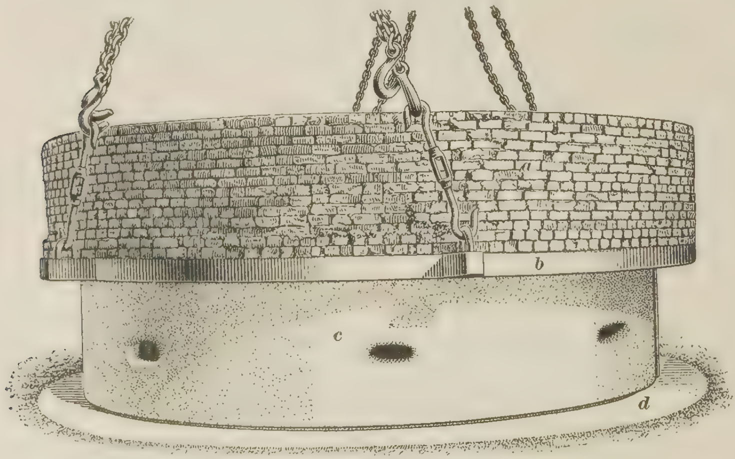


FIG. 44

83. Closing and Securing Mold.—The mold is closed by lowering the outer wall, or cope, over the inner part as shown in Fig. 44, until the ring *b* rests on the surface *d*. Dough rolls are laid between the two to insure a tight joint. The distance between the cope and the inner part of the mold is gauged at several points on the circumference and the cope is adjusted until it is at the same distance from the inner part all around. Flat cores of the form shown in Fig. 41 are then used to cover the rim, dough rolls being used to insure tight joints. Curbing is next erected around the mold

and backing sand is rammed tightly inside and outside the mold to prevent it from bursting. Runners are built so

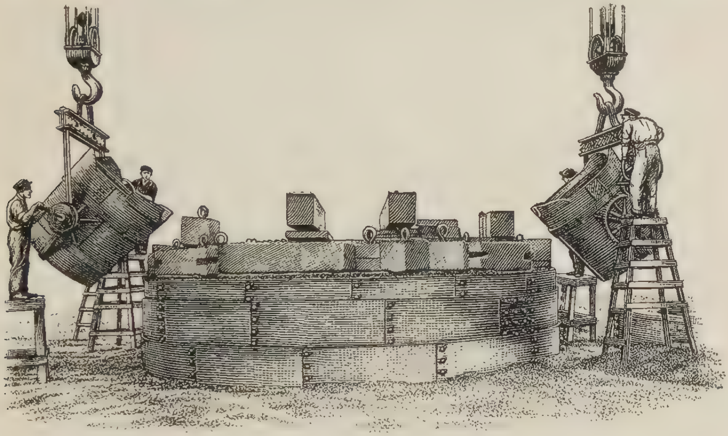


Fig. 45

that the mold can be poured through the hub, and then the mold is heavily weighted. The completed mold, ready for

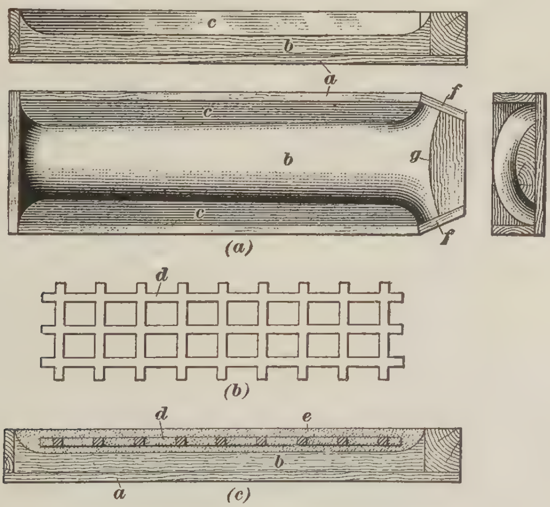


Fig. 46

casting, is shown in Fig. 45. The heavy cast-iron blocks on top furnish the necessary weighting.

84. Core Box for Arms.—The dry-sand cores *i*, Fig. 40, are made in the core box shown in Fig. 46 (*a*). The box *a* itself is a plain rectangular affair, having a total depth inside equal to the depth of the core *i*, Fig. 40. In the bottom of the core box, Fig. 46, is a pattern *b* for half an arm. The core is formed by ramming sand into the box above the pattern *b* and at the sides, in the spaces marked *c*. To stiffen the core and enable it to be handled without breaking, a core arbor *d* is used, as shown in (*b*). It is a cast-iron frame, the bars of which are about 1 inch square in section. A section lengthwise through the core box is shown in (*c*). The arm pattern *b* is at the bottom of the box *a* and the core arbor *d* is firmly embedded in the sand *e* midway between the face of the pattern and the top of the box. The hub end of the core is beveled at each side, as shown at *f*, so as to fit snugly against the adjacent cores.

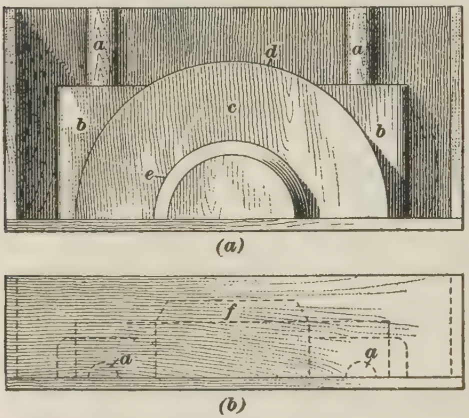


FIG. 47

85. Core Box for Hub.—The cores in which the ends of the hub are formed are made in halves, as shown at *d* and *e*, Fig. 42, and are set on opposite sides of the splitting core *f*. Each half-core is made in a core box like that shown in Fig. 47 (*a*) and (*b*). The prints *a* for the hub-bolt cores lie against the bottom of the core box. The lugs *b* for the bolts extend all the way in to the arm. The part *c* forms the recess for the hub and its outer edge *d* has the same radius as the curved face *g*, Fig. 46. The inner edge *e* has the same curvature as the core for the hub. A print is formed at *f* for the end of the hub core. The prints for the other halves of the hub-bolt cores *a* and lugs *b*, Fig. 47, are formed in the ends of four

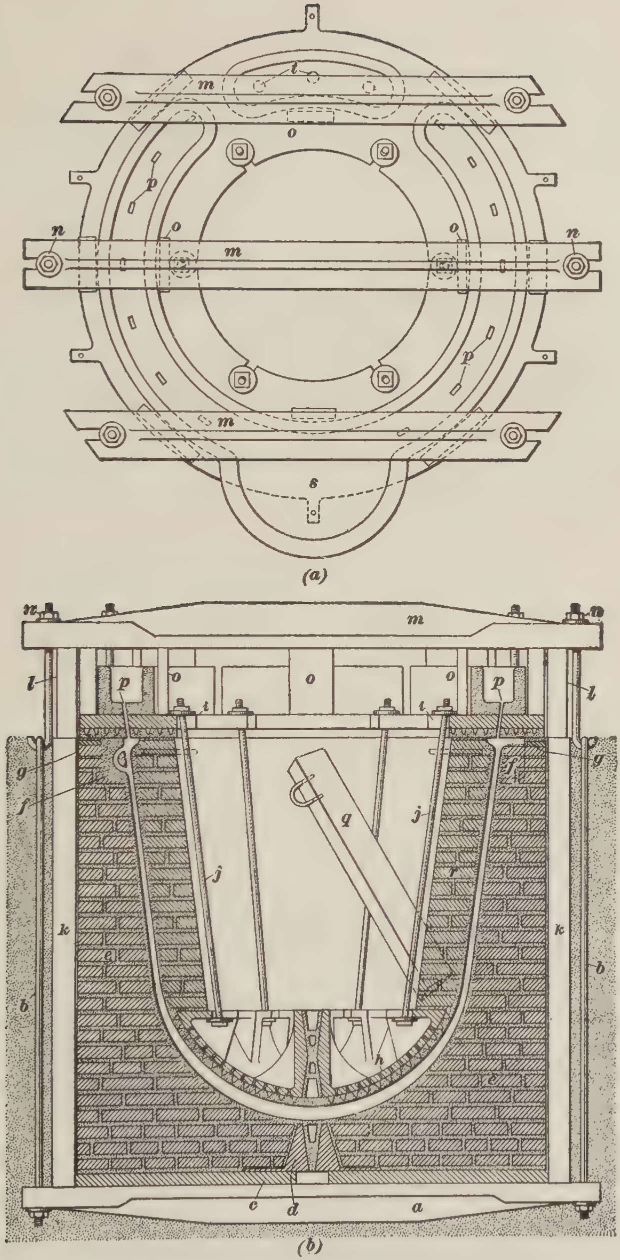


FIG. 48

of the arm cores, by placing in the core box, Fig. 46 (*a*), loose pieces, set into the box at *g*. Right- and left-hand pieces must be provided. The appearance of these loose pieces resembles that of *a* and *b*, Fig. 47, (*a*), but the under surface of *b* must fit the curved surfaces at *g*, of the half-pattern *b*, Fig. 46 (*a*).

PERMANENT LOAM MOLD FOR LARGE KETTLE

86. Preparing to Make Mold.—A plan of a mold for a large kettle is shown in Fig. 48 (*a*) and a vertical section through the assembled mold is illustrated in (*b*). The first thing to do in preparing to make the mold is to dig a pit large enough to contain the mold and leave room for backing sand

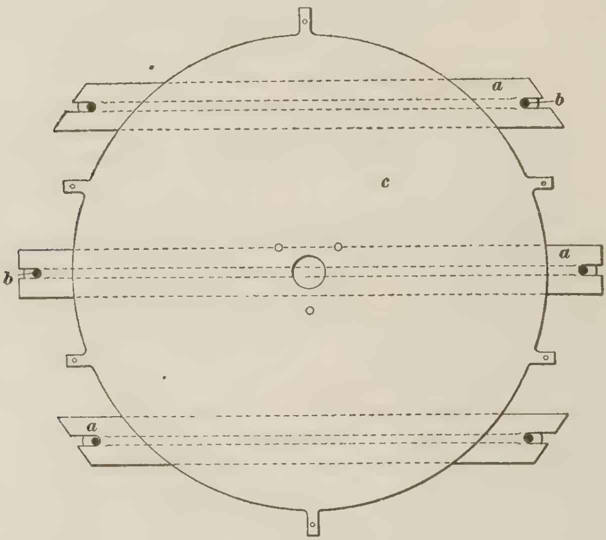


FIG. 49

to be rammed in around it. To insure safety, curbing ought to be used in most cases; or, still better, a pit lined with concrete may be used. The rigging for the mold should be made from the drawings while the pit is being prepared, so as to save time. The binders *a* are cast-iron bars strengthened beneath by ribs and slotted at the ends to receive the rods *b*

by which the mold is clamped together. The binders are first spaced properly on the bottom of the pit, with their flat surfaces uppermost. The cast-iron bottom plate *c* is then laid on them, care being taken to see that it bears evenly on each binder. Instead of the plate and the binders, a single heavy plate with lifting lugs could be used; but it would require much metal that could be used otherwise to better advantage. A plan of the binders and bottom plate is shown in Fig. 49, *a* being the binders, *b* the clamping bolts or rods, and *c* the bottom plate.

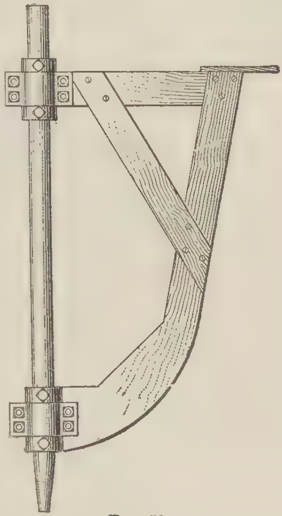


Fig. 50

87. Making Outside of Mold. The bottom plate *c*, Fig. 48 (*b*), has three holes near the center, through which pass bolts by which the spindle seat *d* is held firmly. The spindle is set into the seat, in which it may rotate, and the sweep is fastened to the sweep arm. The cutting edge of the sweep, as shown in Fig. 50, has the outline of the outer surface of the kettle. The outside wall of the mold is built of bricks, as shown at *e*, Fig. 48 (*b*), to within $\frac{3}{8}$ or $\frac{1}{2}$ inch of the edge of the sweep and the remaining space is then filled with loam and swept up to shape. If the soft bricks used are not of good quality, the face of the wall should be made of firebrick, the soft bricks being used in the backing. When the wall has been completed to within about 1 foot of the top, the circumference of the inner circle of the wall should be divided into eight equal parts, and at the points of division iron boxes should be built into the wall, as at *f*. One of these boxes is shown in Fig. 51. It contains a core, as for a handle, bracket, or lug; thus, the wall will not be disturbed when the casting is lifted out, and the mold can be used repeatedly.

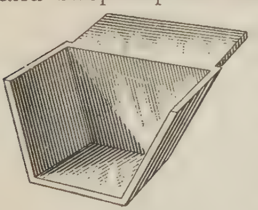


Fig. 51

88. When the outer wall has been built up to about the required height, a strong cast-iron ring *g*, Fig. 48 (*b*), is laid on the top. The form of this ring is clearly shown in Fig. 52. The eight recesses *a* are made so that the ring will clear the boxes set in the top of the wall and will not press on them. The lugs on the outer edge are the same in number and position as those on the bottom plate. This is necessary because the ring and the bottom plate are joined by bolts that clamp the mold together firmly. The outer diameter of the ring is equal to that of the bottom plate. After the ring *g*, Fig. 48,

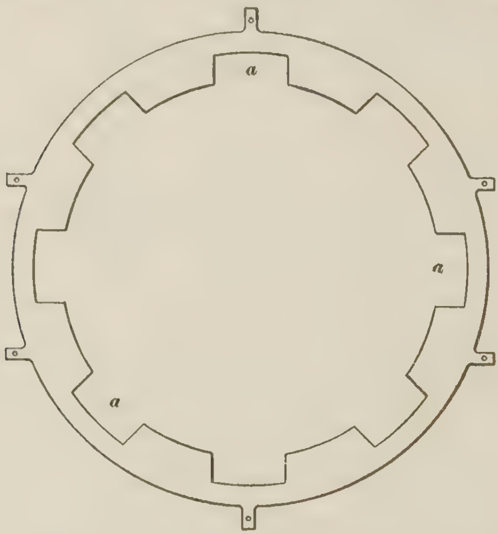


FIG. 52

is in place, the top of the mold is finished off with a coat of loam. In building up the wall *e*, plenty of fine cinders should be tamped into the spaces between the bricks, so that the gases formed during pouring will be led quickly to the outside of the mold, where some provision should be made for their escape.

89. Making Core.—The core for the acid kettle is built on a crown plate *h*, Fig. 48 (*b*). This plate is swept up in loam, with a straight hole cored through its hub, and the

hole is afterwards machined to match the taper of the spindle. It is bolted to a roll-over plate *a*, Fig. 53, the spindle *b* is set in and plumbed, loam is put on, and the surface is swept

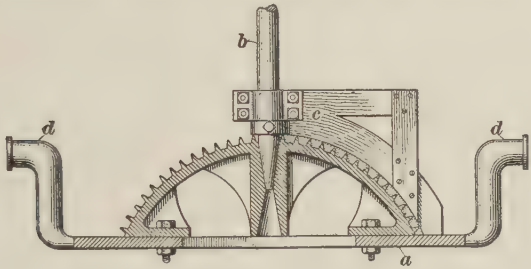


FIG. 53

up with the sweep *c*. After being dried hard by a torch or a fire-basket, slings are attached to the trunnions *d* and it is rolled over and placed on a dummy *a*, Fig. 54. The dummy is a support of brickwork faced with loam that is swept up

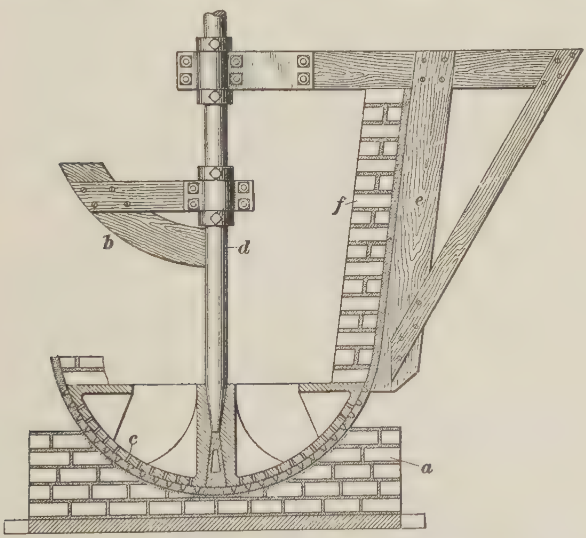


FIG. 54

by a sweep *b* to the same curvature as the bottom *c* of the core. The spindle *d* is now set in the opposite end of the spindle seat, the sweep *e* is adjusted, and the remainder of

the core is built. The loam facing is swept up against a backing wall *f*, as in the construction of the outside of the mold. When the core is finished, an iron lifting ring is secured on top of it and it is lifted and set on the oven carriage, supported by a dummy similar to that shown at *a*.

90. Assembling Mold for Acid Kettle.—When the parts of the mold are dry, they are put together as shown in Fig. 48 (*b*). The lifting ring on the core is removed and the top plate *i* is bolted on in place of it. The top plate is of the same diameter as the bottom plate and has prickers on the under surface to hold the loam. It is bolted to the crown plate by long bolts *j*, thus binding the core securely. The core is lifted by the top plate and lowered into the cope. It is centered by means of center lines drawn on the top of the cope and on the top plate, as described in connection with the mold for a cylinder. The gates, risers, and runners are arranged as shown in (*a*), which is a top view of the mold. The molten metal is poured into the runner basin *s*, from which it flows to the gates *p* and through them into the mold. At *t* are risers opening into a riser basin. The binders *m* are like those put beneath the bottom plate and are joined to them by bolts, thus securing the mold. When constructed as described, the mold can be used repeatedly and will last for several years of continuous service.

91. At each end of each binder *a*, Fig. 48 (*b*), a cast-iron standard *k* is set, making six in all. On the top of each standard a block *l* of iron is set, on which the end of a top binder *m* rests. In this way, the pressure exerted when the nuts *n* are tightened is prevented from crushing the mold. When the nuts are screwed down as tightly as possible, iron packing blocks *o* are wedged tightly between the binders *m* and the top plate *i* to clamp the mold together. The mold is poured from the top, the pouring gates being shown at *p*. Holes are cast in the top plate to correspond to these gates. A long bar *q* of cast iron having a wedge-shaped cross-section is built into the wall *r* of the core. After the casting is poured and the metal has set, this bar is pulled out of the core, as in the

position shown, leaving a V-shaped opening in the core wall from top to bottom. When the casting contracts in cooling, this opening will allow the core to be squeezed together, and in this way the casting will be prevented from cracking. All cores must be arranged to be crushed an amount equal to the contraction of the casting, if cracking of the casting is to be avoided.

MOLD OF SAND AND LOAM FOR PIPE

92. Outline of Method.—The method described in the following articles explains the construction of a mold in sand and loam for a pipe bend, though it is equally applicable to a branch pipe or a straight pipe. Very little pattern work is required and the molding is neither tedious nor difficult

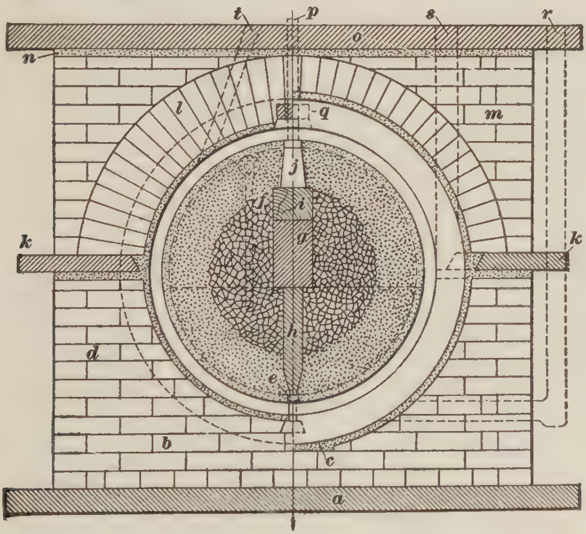


FIG. 55

The outside of the mold is built of bricks on which loam is swept up to the form of the outside of the pipe. The core is made of sand, because it can be made more quickly than in loam; also, it is much easier to knock out after the casting is made, and there is less danger of its cracking the casting.

93. Lower Half of Mold.—A vertical section of the completed mold is shown in Fig. 55. The first step is to level up a suitable bottom plate *a*, which may be either round or square, if it is of sufficient size. On this plate at least two courses of bricks *b* are laid. At each end, about where the

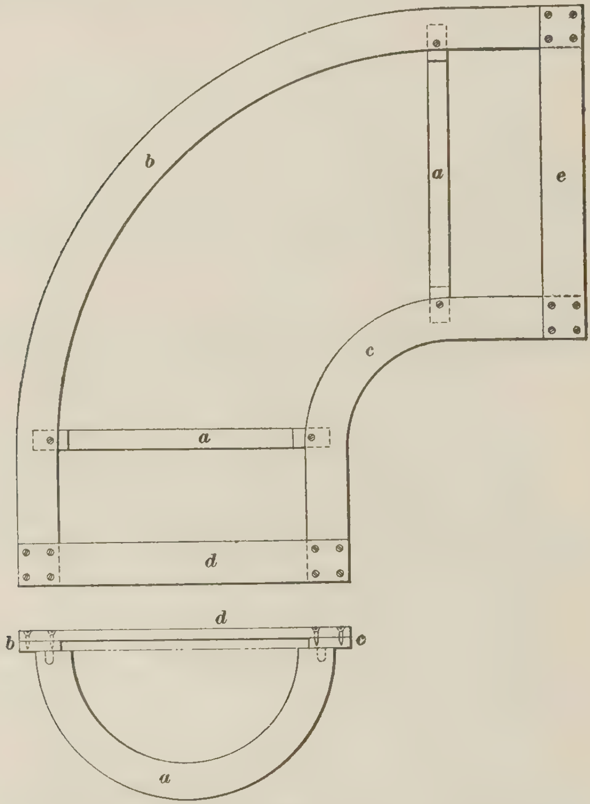


Fig. 56

centers of the lower edges of the pipe flanges will come, a patch of loam *c* is laid. The wooden templet shown in Fig. 56 with the lower flanges attached is then set so that the flanges *a* rest on the loam patches, and the curved strips *b* and *c* are adjusted until they are level, in which position the templet is securely propped. Small sticks resting on the brickwork and

fastened to the templet with brads or nails hold the templet until the brickwork is built up high enough to keep it firmly in place. The under faces of the strips *b* and *c* are on a line with the center of the pipe.

94. Two semicircular sweeps, or strickles, as shown in Fig. 57, must be made. That shown in (*a*) has a cutting edge with a radius equal to the radius of the outside of the pipe, or 18 inches, and its center lies on the line *a b*. Then, when the top strip *c* is laid on the strips *b* and *c*, Fig. 56, the center line *a b*, Fig. 57 (*a*), will pass through the center of the pipe. The sweep shown in (*b*) has a radius of 16½ inches, or half the inside diameter of the pipe, and its center line *a b* is located below the strip *c* the same distance as in the other. This distance is equal to the thickness of the strips *b* and *c*, Fig. 56. Each of the strickles in Fig. 57 is made with a slot *d* big enough to enable the hand of the workman to be put through. In using the strickle, he pulls it along by grasping it at the top and at the slot.

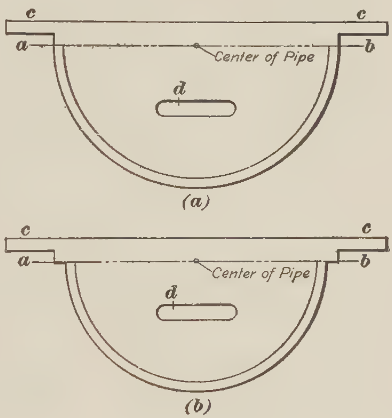


Fig. 57

95. The strickle shown in Fig. 57 (*a*) is laid on the strips *b* and *c* of the templet, Fig. 56, and brickwork is built up to conform to the curve of the pipe, to within about ½ inch of the edge of the strickle. This brickwork is shown at *d*, Fig. 55. Loam is then put on the brick and swept up with the strickle, thus forming the lower outside face of the mold, between the flanges. The strickle shown in Fig. 57 (*b*) is then used on the parts of the templet between the flanges *a*, Fig. 56, and the end strips *d*, and loam is swept up on the wall as before, thus forming the lower half of the core print at each end of the mold. The work is dried until it is hard and then the

part between the flanges *a* is given a coat of good, tough sand equal in thickness to the thickness of the pipe, or $1\frac{1}{2}$ inches. This coat is swept up by using the strickle in Fig. 57 (*b*) between the flanges of the templet. There will then be a continuous half mold from end to end with a radius equal to the inner radius of the pipe. This half mold is smoothed with finishing tools and parting sand is rubbed on the whole surface.

96. Building Core.—About $\frac{1}{2}$ inch of core sand is put on the surface of the lower half that has just been finished

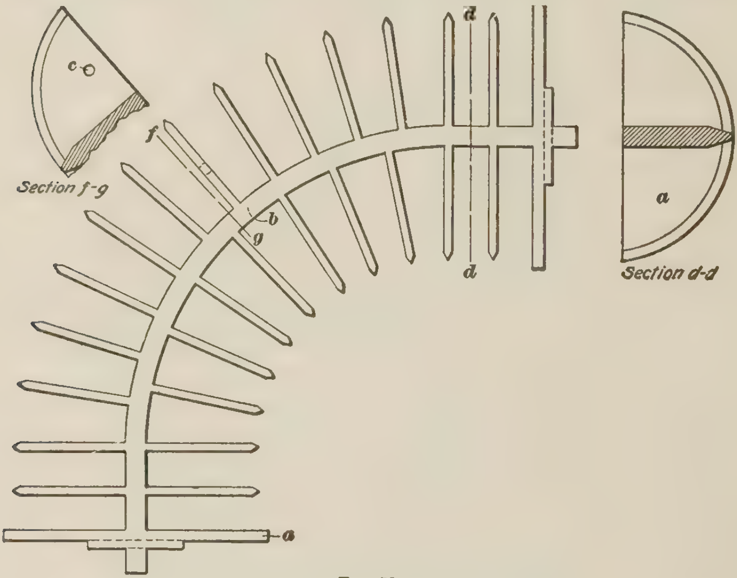


FIG. 58

and then the arbor shown in Fig. 58 is set in. It is a cast-iron frame on which the core is built to the outline of the inside of the pipe. The sand that is built up on it must not be wet, though it should be well mixed and tempered. A core that is rammed in a box and rolled over on a plate to dry may be made with wet and badly tempered sand; but a core that is to be lifted out of its form and dried cannot be made of wet sand. Even if the lifting out should be done successfully, the bottom would drop off in scabs while being dried.

The arbor must have gaggers of suitable length and the sand must be rammed very hard and have no soft spots in it. The ends *a* are supported by the core prints, and it is necessary to support the middle at a point *b*, at the under side of the core. This is shown in Fig. 55 by the chaplet *e*, which bears on an opposite chaplet support brought up from the bottom of the mold.

97. Plenty of cinders should be used in building the core. Between the bars of the arbor they should be used freely and when the top of the arbor is reached, large cinders or lumps of cupola slag should be laid along its whole length, allowing about 5 inches for sand on top to complete the core. Facing sand need not be used. Well-tempered heap sand should be used for the most part, with a facing of only 1 inch or so. Coke is often used instead of cinders for venting, but it is much more expensive. The top half of the core is swept to correct shape and size with the strickle shown in Fig. 59 (*a*). The radius of its cutting edge is equal to the radius of the inside of the pipe and its center line *a b* is below the edge *c d* an amount equal to the thickness of the strips *b* and *c*, Fig. 56. The top surface of the core is now finished with tools, but not blackened. Next, a layer of riddled and tempered sand $1\frac{1}{2}$ inches thick is put on, tamped lightly, and swept up to shape with the strickle shown in Fig. 59 (*b*), which resembles the one in (*a*), except that it has a radius of 18 inches. The core prints are built up in the same way as the core body and are swept off finally with the sweep shown in (*b*).

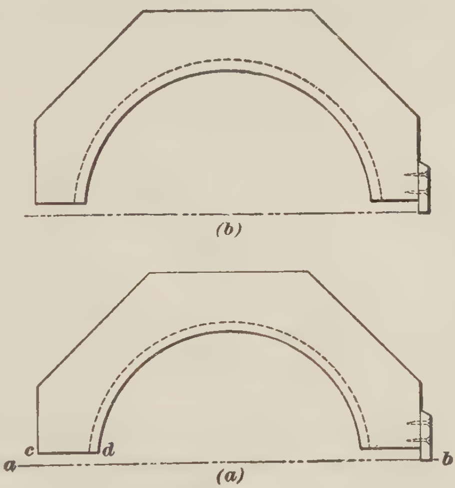


FIG. 59

98. During the construction of the core a lifting bolt *f*, Fig. 55, must be set into it. The lower end of the bolt is formed into a hook that is passed through a hole in one of the quadrants of the arbor near the middle of the bend, as shown at *c*, Fig. 58. The lifting bolt must not be so long as to reach the surface of the core, but should be covered by the facing sand. To prevent the core from floating, a chaplet must be used at the top, near the middle of the bend, and a chaplet bearing must be carried up from the arbor to the top of the core. For example, an iron block *g*, Fig. 55, is set on the arbor *h*, a block of wood *i* is set on the iron block, and then an iron block *j* long enough to reach the surface of the core is set on the wooden block. The object of using one

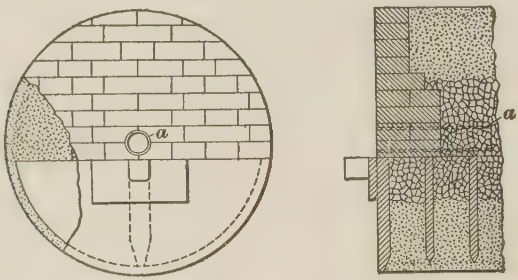


Fig. 60

wooden block instead of all iron blocks is to allow the core to be compressed when the pipe contracts, as a rigid piece of iron from top to bottom across the center might cause the pipe to crack when contraction occurs. The wood will be charred somewhat during pouring, and be compressed. To prevent unsightly finish to the core, the top half of each end may be bricked up on top of the arbor as shown in Fig. 60. An opening must be left in the brickwork at the center, or a piece of pipe *a* may be set in, reaching back into the cinders, to enable the gases to escape.

99. Setting Top Halves of Flanges.—After the core is completed, the templet is removed. To do this, the screws attaching the strips *b* and *c*, Fig. 56, to the lower halves *a* of the flanges are drawn out and the templet, composed of the

strips *b* and *c* and the end strips *d* and *e*, is lifted away as one piece, leaving the halves *a* of the flanges still in place. The joint, or the surface on which the strips *b* and *c* rested, is now slicked up and any ridges on the core where the edge of the templet rested are smoothed off. The top halves of the flanges are now set on the lower halves, to which they should be fitted with dowel-pins, as shown at *a*, Fig. 61. The outside radius of the upper and lower halves is the same; but the upper half *b* has an inner radius greater than that of the lower half *c* by an amount equal to the thickness of the pipe. The upper halves are trued up with a square and the core prints are trimmed to conform to them. If the flanges show a tendency to shift, they should be held by a few spikes driven into the core beside them.

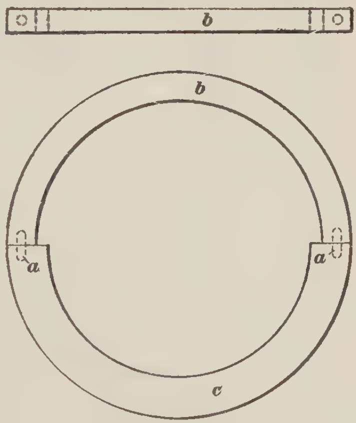


Fig. 61

100. Top Half of Mold. The next step is to set on the cope ring *k*, Fig. 55, after which the upper part of the mold is built. As the building proceeds, the core is covered with about ½ inch of loam, against which the brickwork is built in the form of an arch *l*, so that it is self-supporting. The backing *m* is then completed and a layer of mud *n* is spread on top to form a bearing for the top plate *o*. The top plate may be bolted to the cope ring and the top of the mold lifted by the top plate; or the top plate may be left unbolted and the upper part of the mold lifted by the cope ring. Marks should be made at the joint of the mold, as previously explained, so that the parts can be set together again accurately. The cope, or top half of the mold, is now lifted off and placed on stands and the inner surface is finished and blackened. If the blackening is done with a sprayer, the task is easier and less distasteful than when a brush or swab is used.

101. Removal of Core and Assembling.—The removal of the cope leaves the upper half of the core exposed, covered with sand to the thickness of the casting. This sand is now scraped off to the surface of the core. Then slings with turnbuckles are attached to the end lugs and the lifting bolt *f*, Fig. 55, and the core is lifted out of the lower part of the mold. It is set on the three bottom bearings, namely, the ends of the arbor and the bottom chaplet bearing, and finished and blackened in the usual way. The halves of the flange patterns are removed from the mold, the layer of sand representing the thickness of the metal is then scraped out of the lower half of the mold and the latter is dried. In assembling the mold, there is nothing to do but to put the proper size of chaplet *e* at the bottom, to lower the core into place, and to set on the top half according to the marks made at the joint. A chaplet must be set in on top to prevent the core from floating. It may have a stem *p* carried through to the outside of the mold so that it can be weighted down; or it may rest firmly against a bearing *q* in the upper part of the mold. The mold may be made self-contained by bolting the top and bottom plates together. A curbing is built around the mold and sand is rammed in, as before.

102. Making Pipe Mold in Sand.—The pipe bend or any other pipe section may be made in sand, if desired. A hole is dug in the floor to conform to the outline of the pipe, as nearly as possible. The wooden templet is laid on and leveled up, the flanges being set square with it. Sand is rammed up firmly and formed with the strickles in the same way as when making the mold in loam. The core is built up in the same manner. A cope of suitable size and form is then set on top and the upper part of the mold rammed up in it.

103. Gating of Pipe Mold.—A large pipe may be run in several different ways. One way is to pour at the bottom of the flange, as shown by the gate *r*, Fig. 55. The vertical flange pour is indicated by the gate *s*. The top pour into the body of the mold is shown at *t*. In each case an effort

is made to have the gate tangential to the core, although with the top body pour this result is difficult to attain. With light pipes this method is safest; but the gate should be smooth and not too tapering, or the contraction of the casting in cooling will cause a piece of the pipe to be broken away and left hanging to it. A hole in thus left in the casting and if it cannot be properly plugged, the casting will be spoiled.

SWEEPING UP CONICAL DRUM

104. A conical drum with a spiral groove for a rope, as commonly used for hoisting, may be swept up in loam. A part of the mold for a drum of this kind, 12 feet in length and 13 feet in diameter at the large end, is shown in Fig. 62.

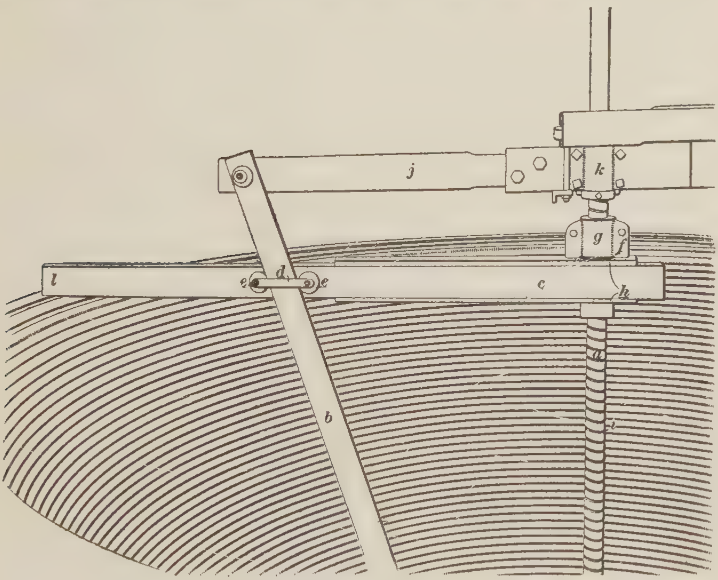


FIG. 62

The inside of the mold is already swept up and the spindle and the sweep are still in place. The first thing is to dig a conical hole in the floor, with the small end at the bottom, which is about 8 feet in diameter. Bricks are laid in loam

on the bottom and the sides of the hole. Each course at the sides is laid out a little beyond the one below it, so that the diameter increases regularly with each course of bricks from the bottom to the top. The spindle *a* has a seat in the bottom very much as in Fig. 16, and fastened rigidly, and the top of the spindle is also fastened so that it cannot move from its place. The thread or groove *i* in the spindle has the same pitch as that of the rope groove in the drum to be cast. The guide *b* is fastened to an arm at the bottom similar to the arm *j* to which it is fastened at the top. Each of these arms has a bearing *k* to which it is attached. The bearings *k* are revolved around the spindle, but are not moved along its axis, as they are held in place by collars.

105. The long sleeve *f*, Fig. 62, carries the slide arm *h* to which it is rigidly attached. In *f* there is a nut *g*, which fits the thread *i* of the spindle and gives the sleeve and arm their upward movement as they are revolved about the spindle. The arm *c* slides in a groove in the long slide *h* and carries a strap *d* that connects the two rollers *e*, and with them moves out the arm *c* as it is carried around and up with the sleeve *f*. This gives the sweep arm the necessary spiral motion to form the mold so as to produce the rope groove in the casting. The spiral is given the correct outline by a sweep bolted to the end *l* of the arm *c*.